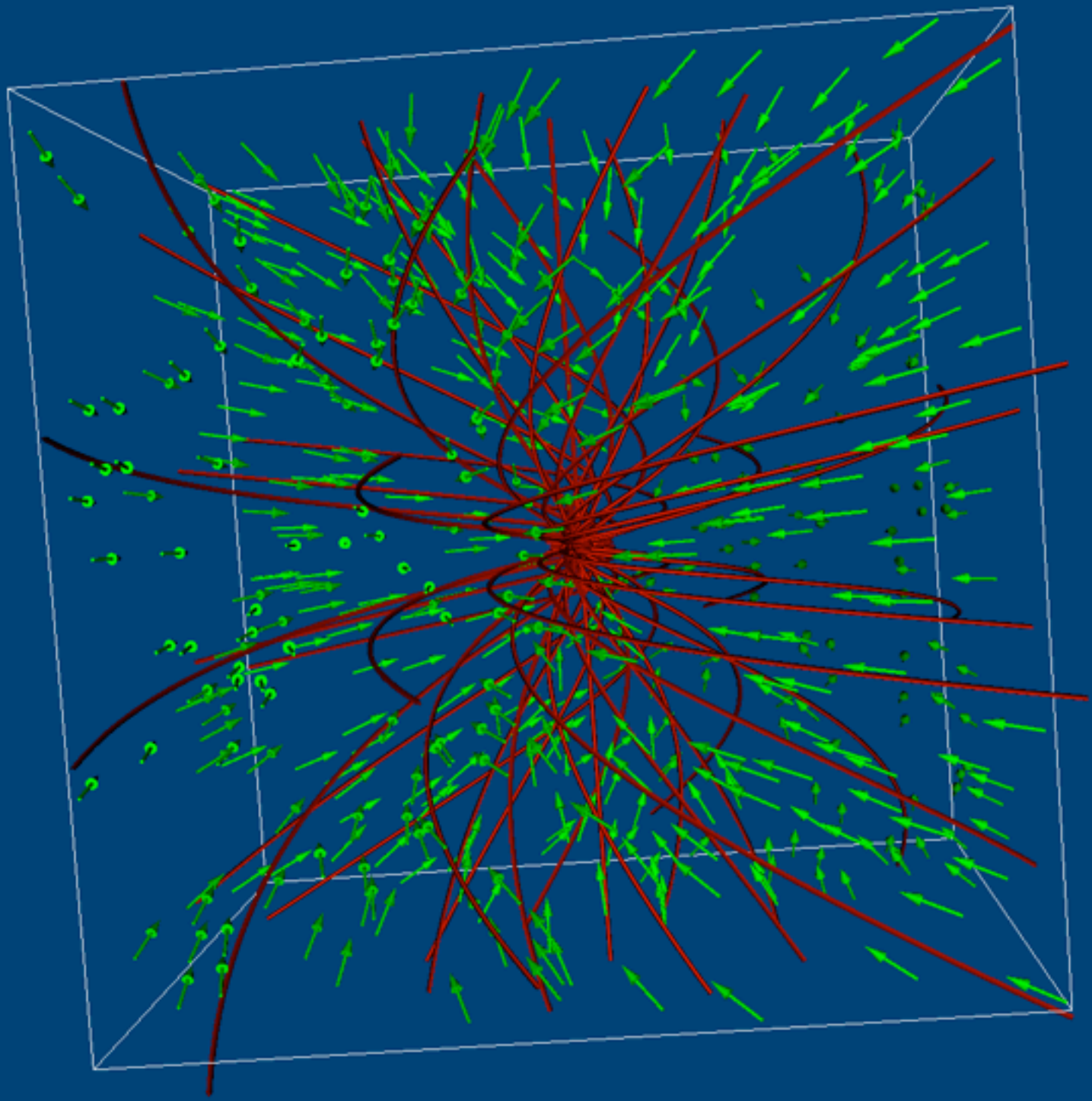
3D Vector Field Visualization

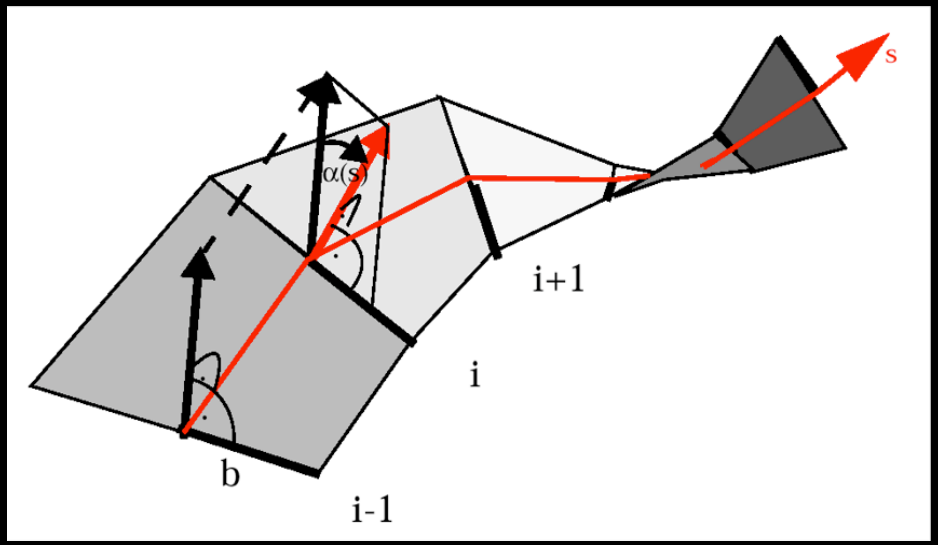


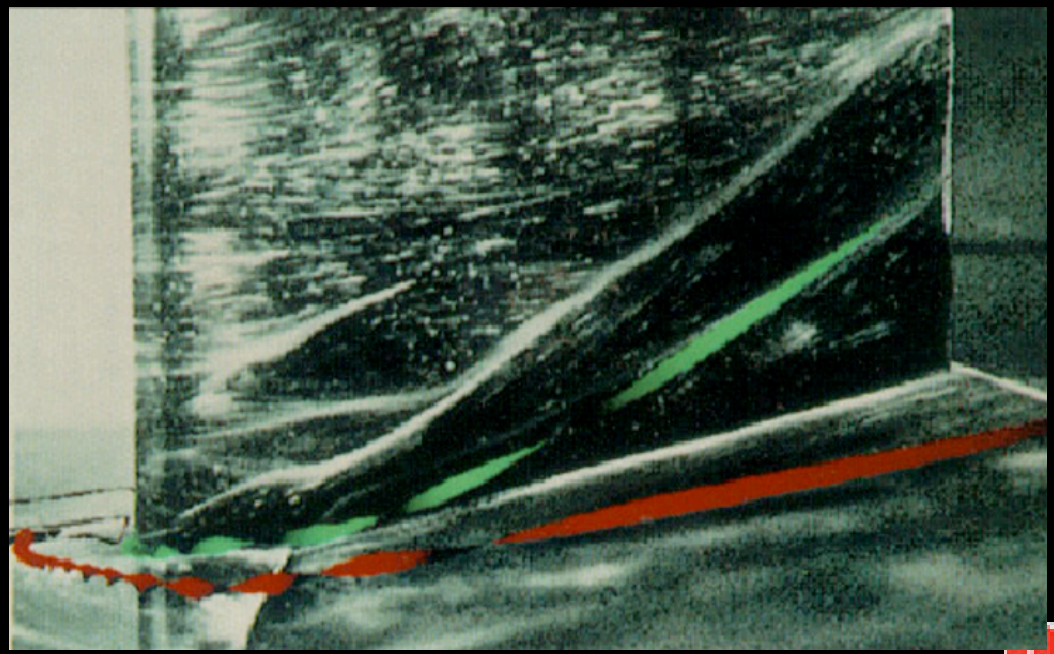
Ribbons

Ribbons can be constructed using 2 or 3 particle advections per segment.

Ribbons can also be calculated using a frenet frame or the angular velocity.

$$\alpha(s) = \int_{s_0}^{s} \omega(s) \; dt$$

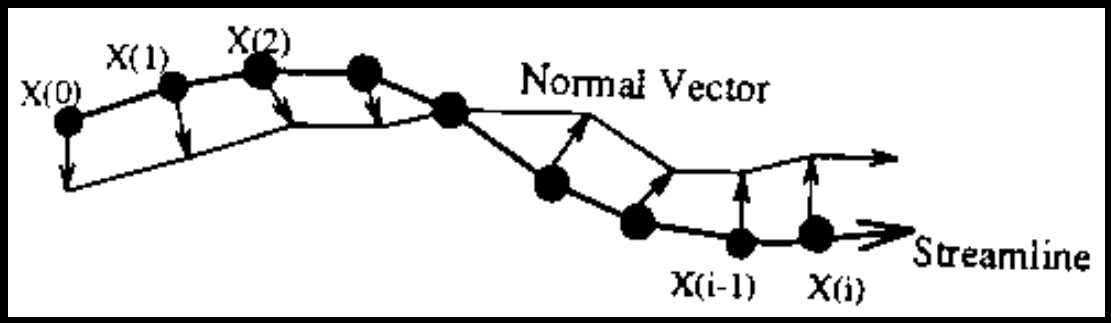




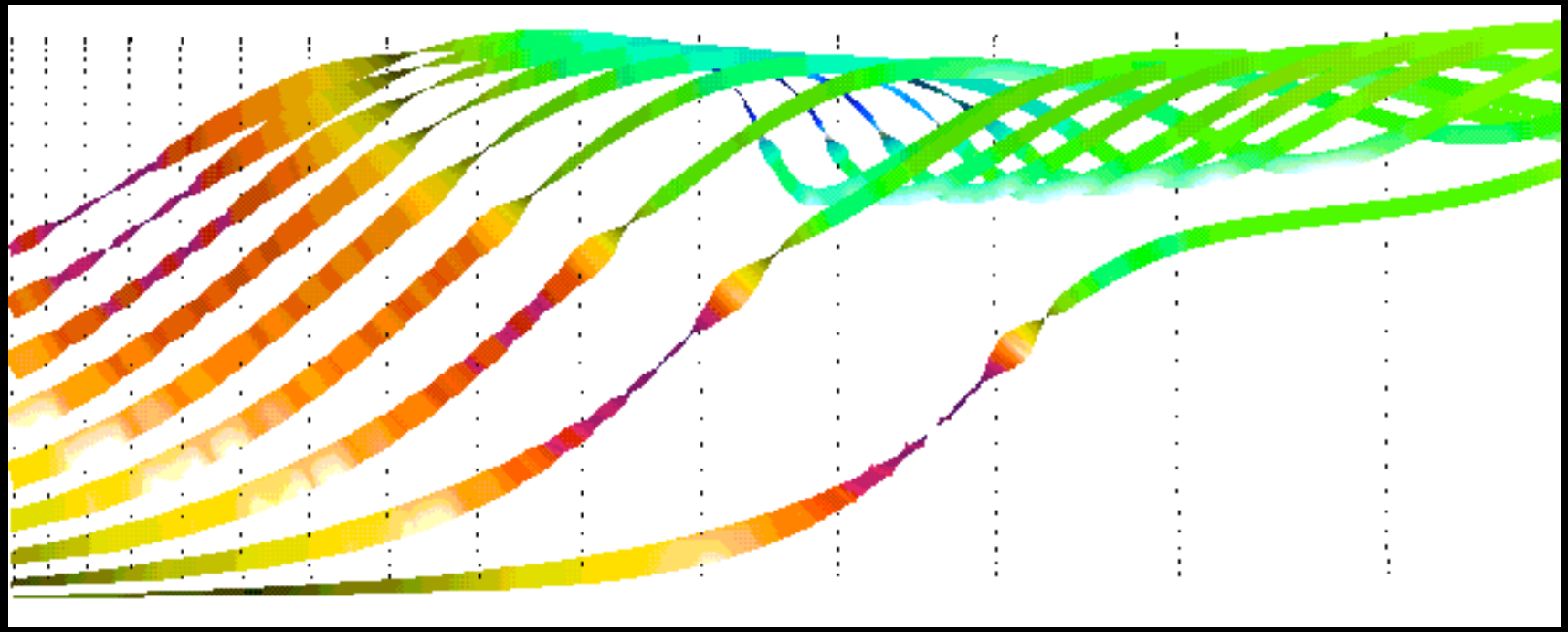
Stream-ribbon

Problem - when flow diverges

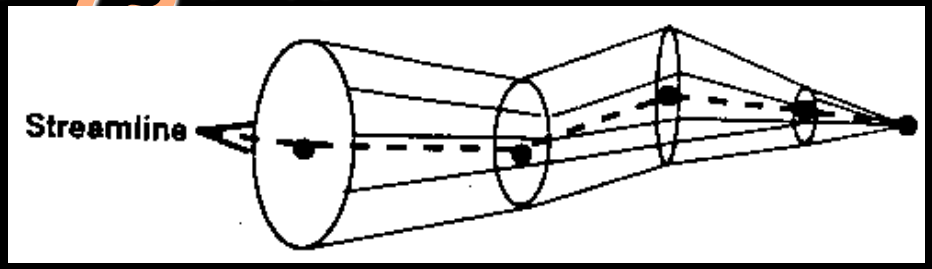
Solution: Just trace one streamline and a constant size vector with it:



Streamribbons

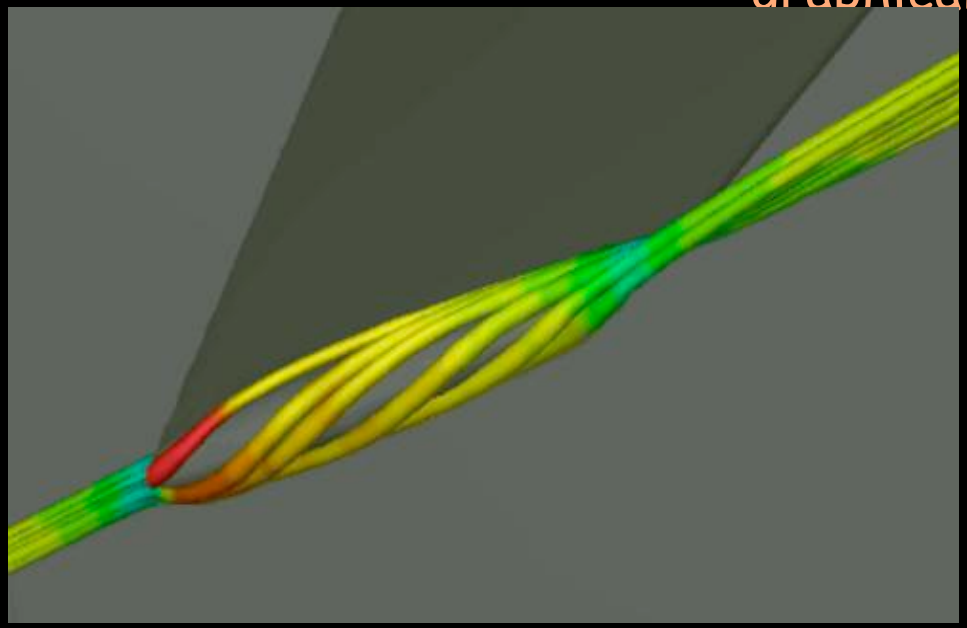


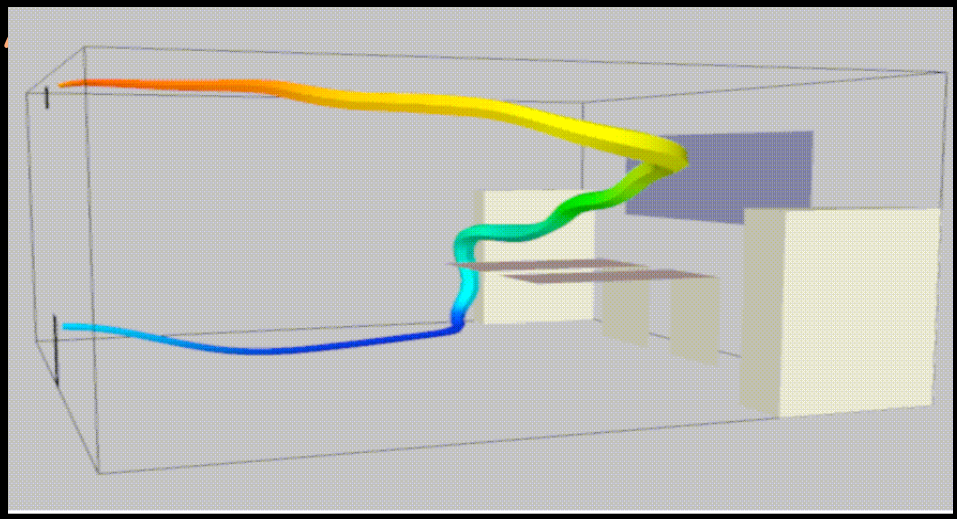
Stream Polygons

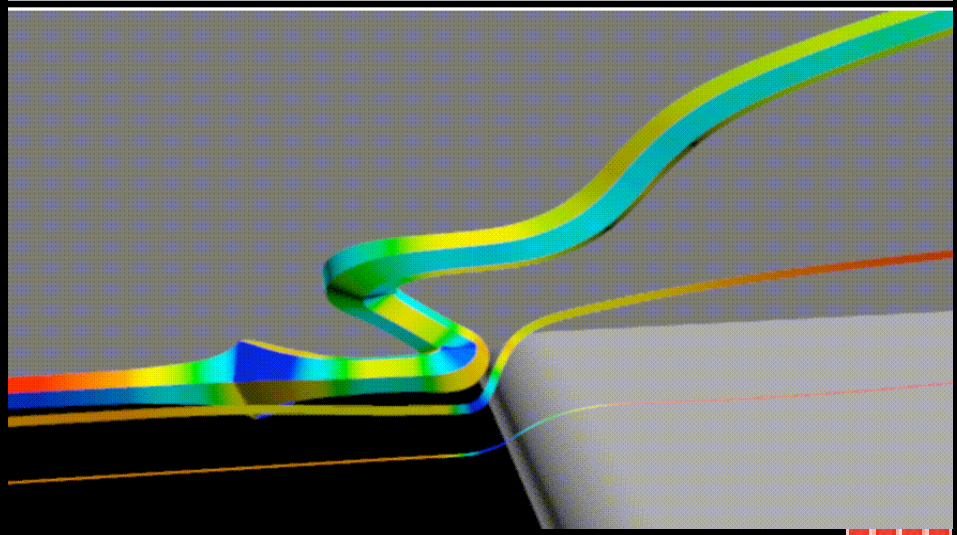


Stream polygons:

- Specify contour, e.g. triangle or circle, and trace it through the flow
- Render the evolving tube with graphical

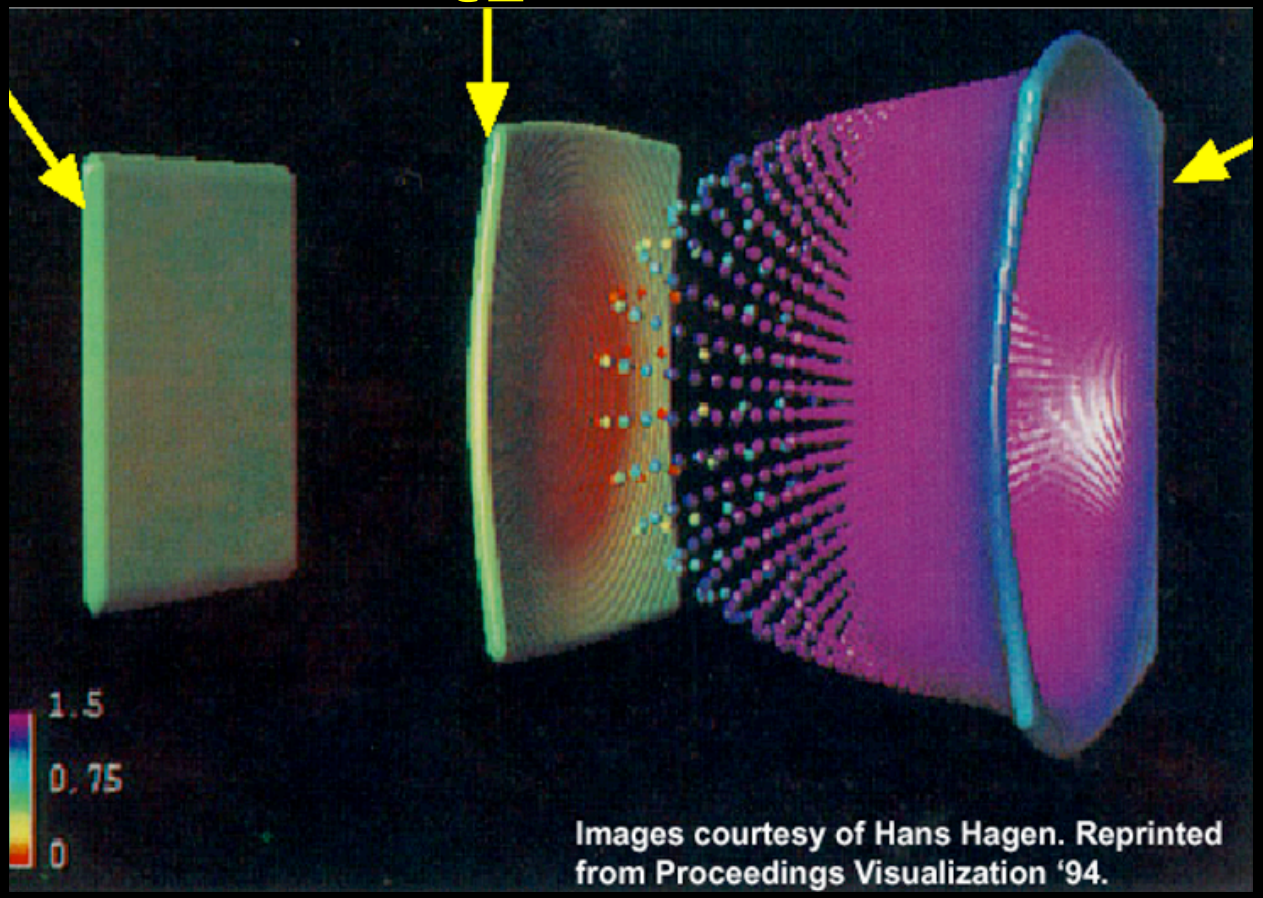






Time Lines

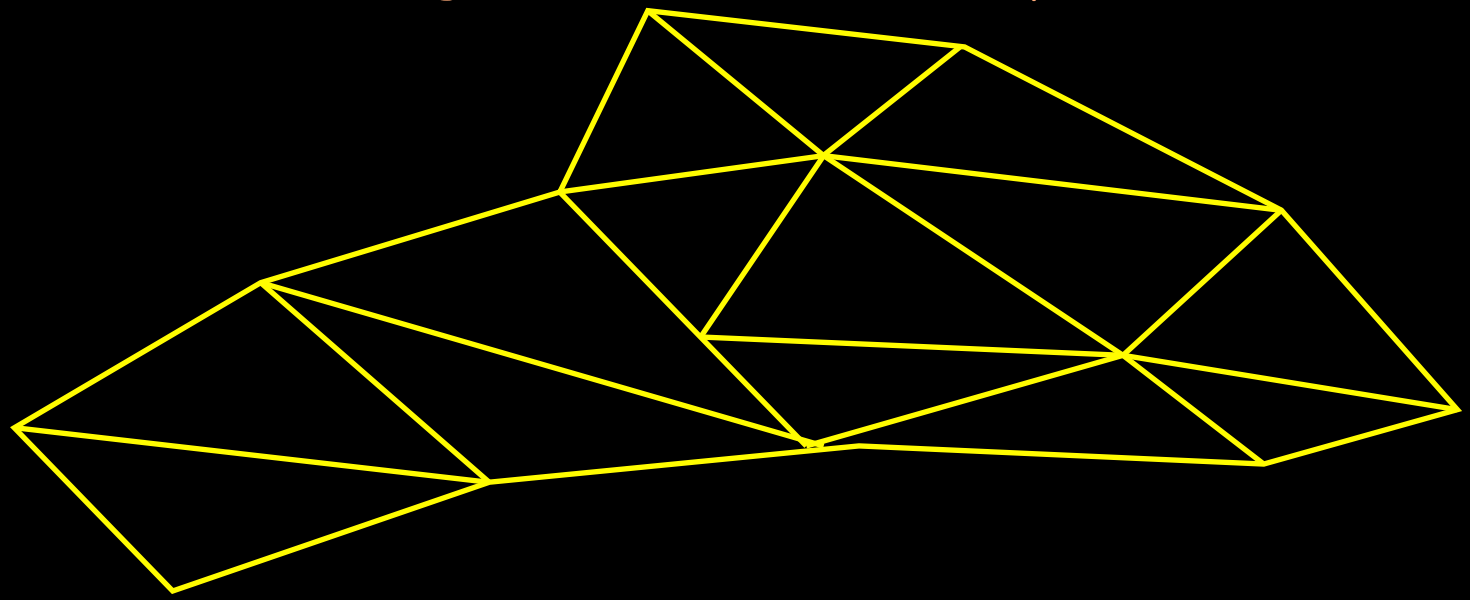
Time-lines or time-surfaces can show the evolution of a flow



Stream Surface - explicit

Stream Surfaces can be generated explicitly as outlined by Hulquist:

- Start with segmented curve
- Advect each vertex forward
- If adjacent vertices diverge, add new vertices
- If adjacent vertices converge, merge the vertices
- If too much divergence, let the surface split and form a tear.



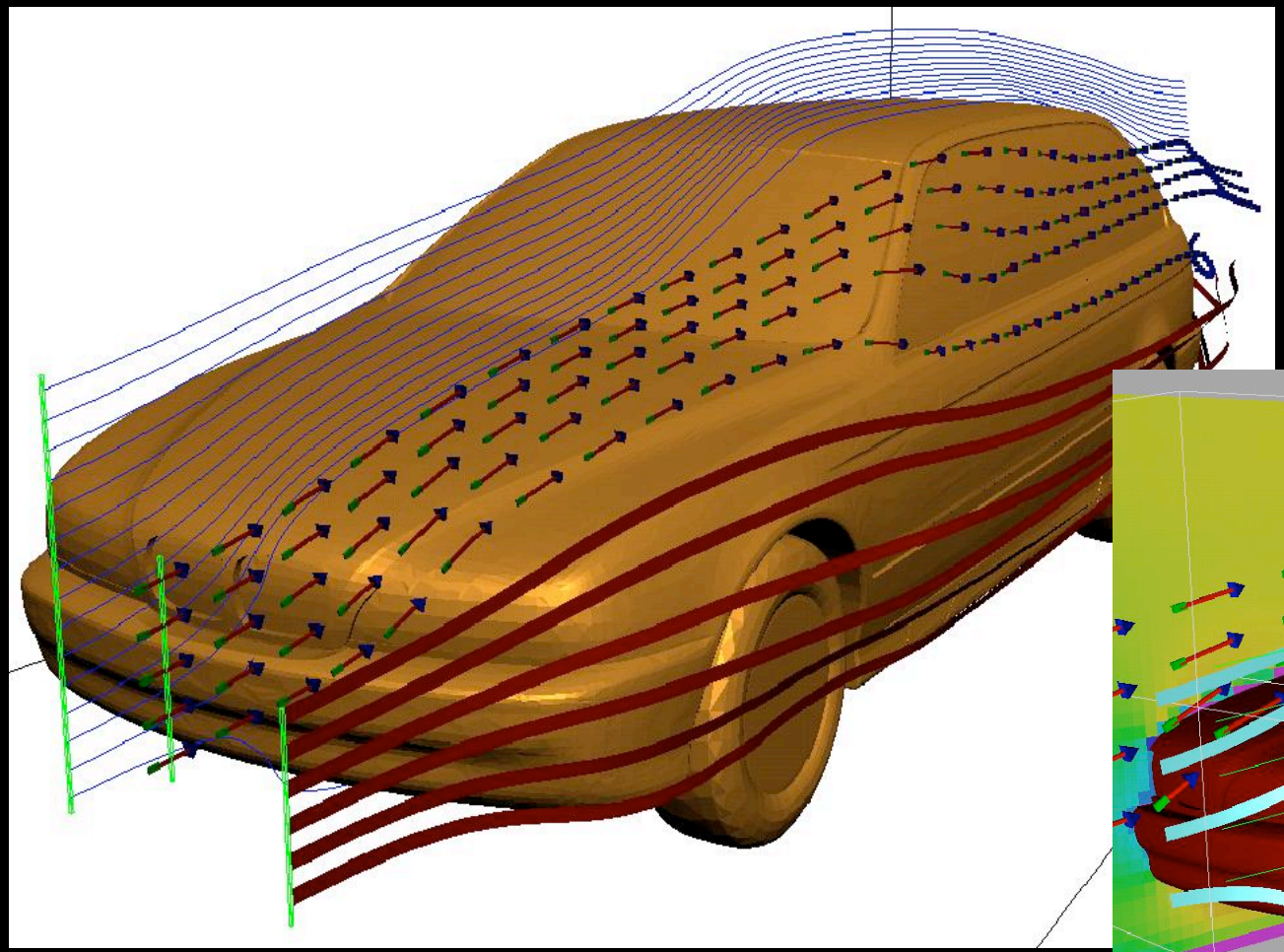
Stream Surface - implicit

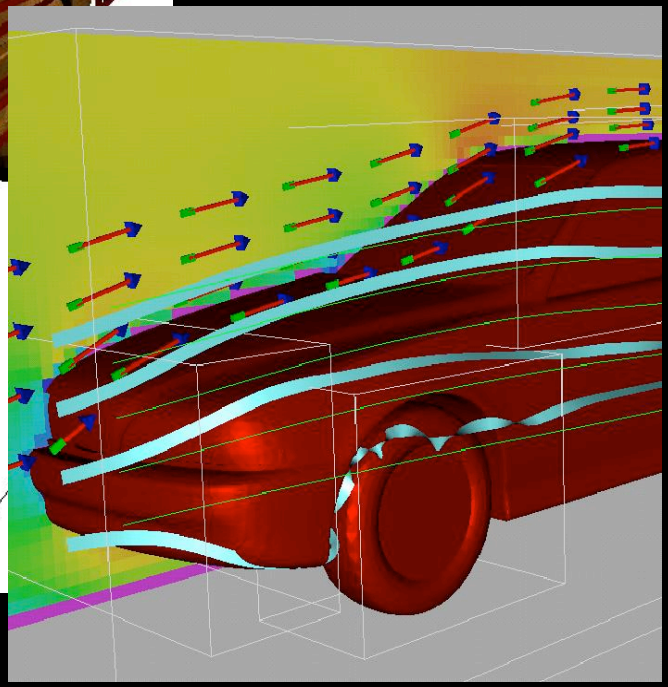
Stream Surfaces can also be generated implicitly as outline by van Wijk:

- Place a continous function on the inlet's of a flow simulation.
- For each sample point, trace backwards to inlet
- The value at the inlet intersected with the streamline is used to generate a function f(x,y,z)
- Take isocontour of the function f(x,y,z) to get a stream surface.

3D vector field visualization

Use all techniques together in order to see what you want

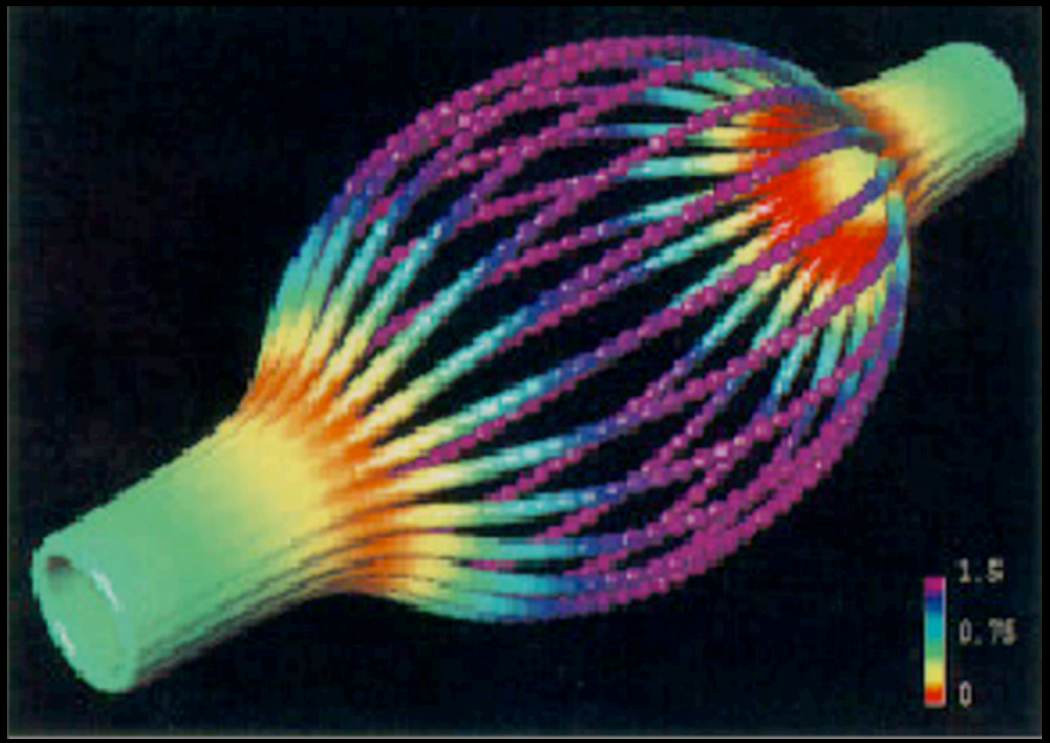




Streamballs

Based on meta-balls

- Implicitly generated surfaces
- Easily split and merge
- Computationally expensive
- Need fine meshing to do accurate isocontouring



Streamballs

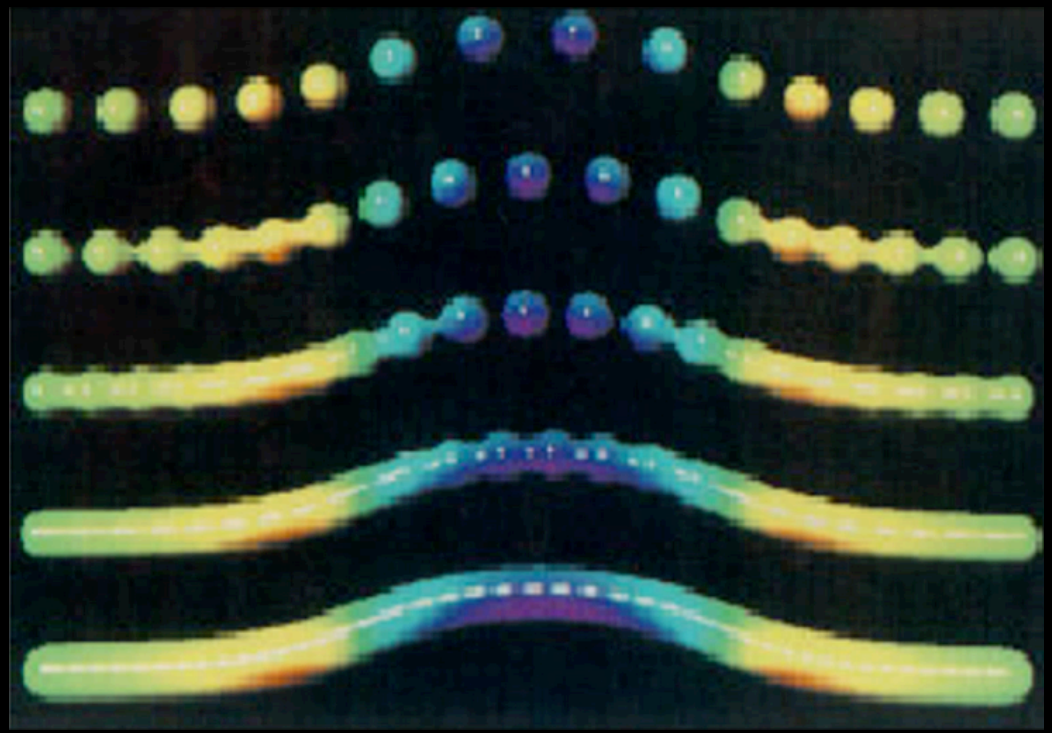
Basic idea is to create a continous function f(x,y,z) and take isocontours of this function.

Use metaballs to generate this function.

Metaballs were developed separately by Nishimura, Blinn, and Wyvill.

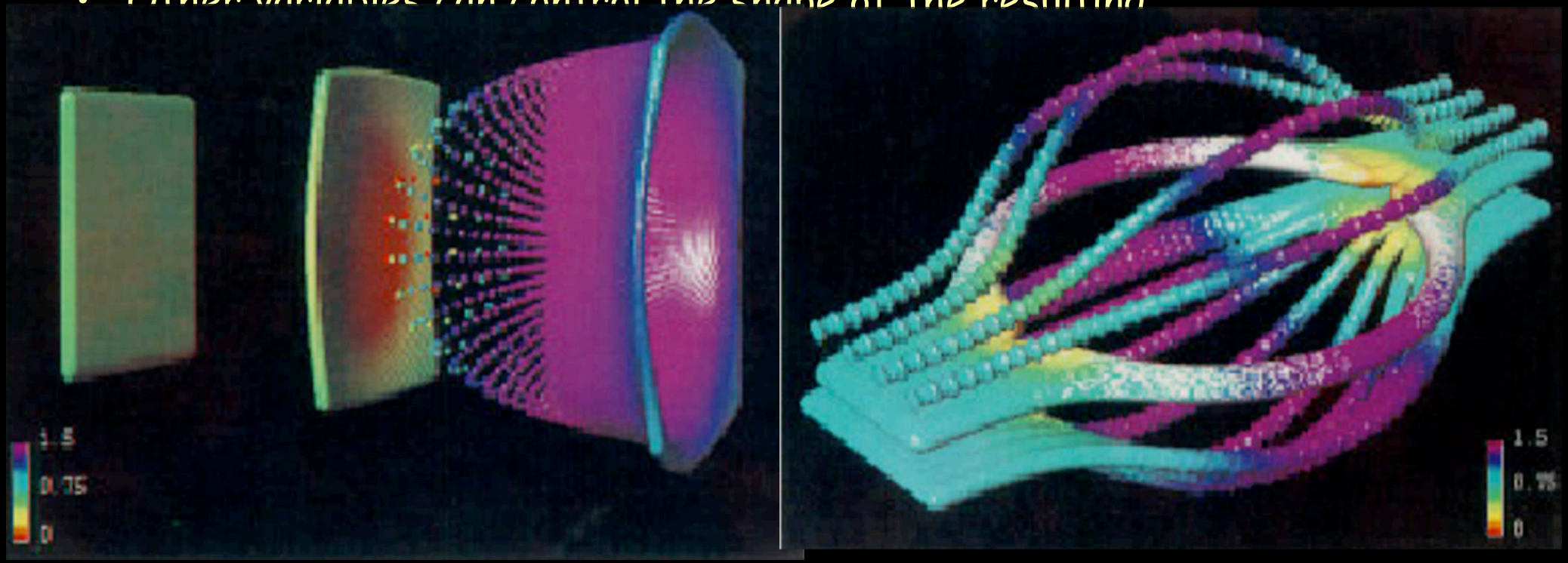
They were further refined by Bloomenthal and Shoemake.

Treat particles as metaballs or use a timeline curve.



Streamballs

- A rake of particles will start out as a stream surface.
- Other variables can easily be mapped to the surface's color and texture.
- Other variables can control the shape of the resulting

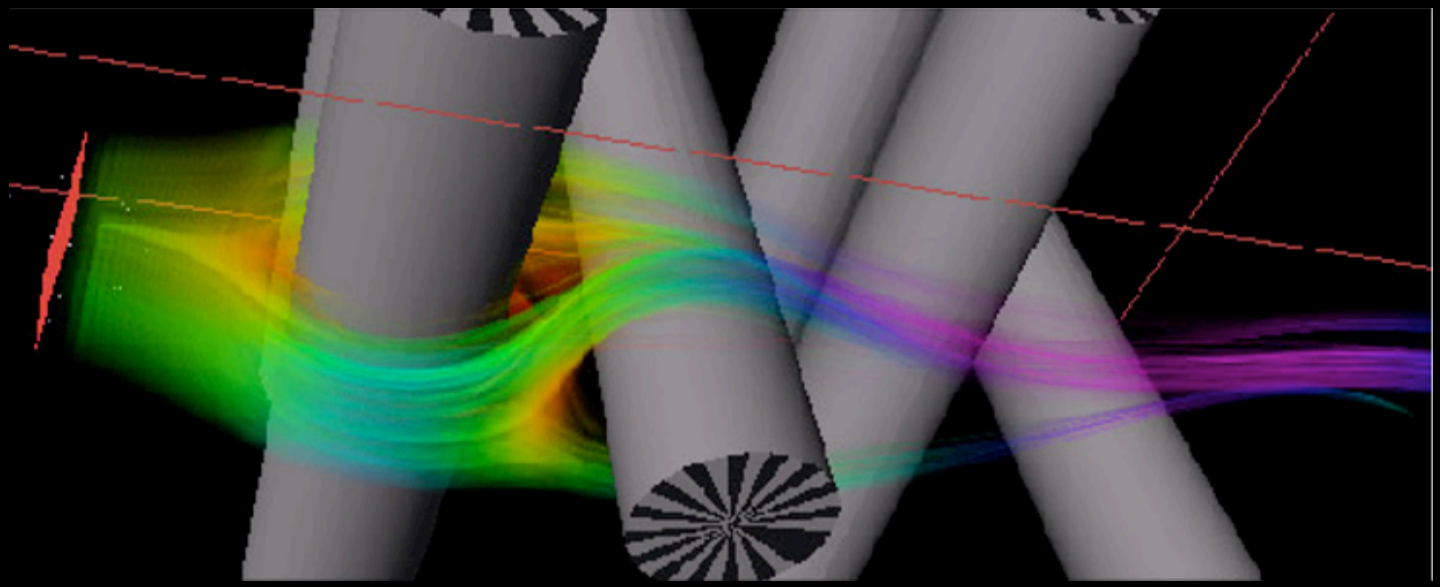


Flow Volumes

Volume rendering and compressibility

Advection through various mesh topologies

Puffs and colored flow volumes



Flow Volumes

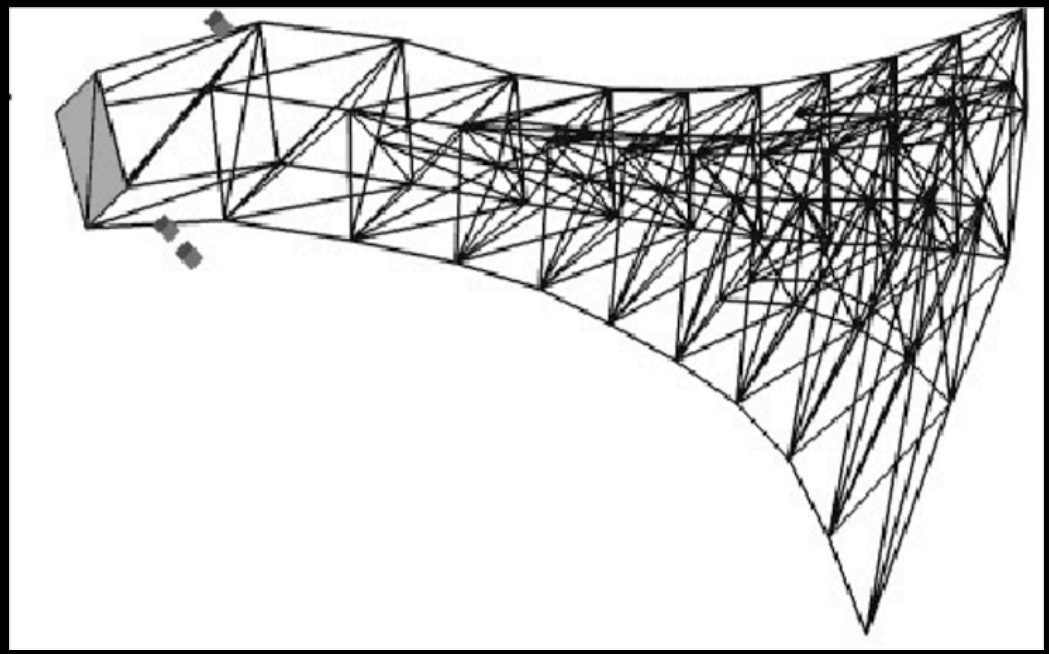
Seed polygon (square) is used as smoke generator.

Constrained such that center is perpendicular to flow.

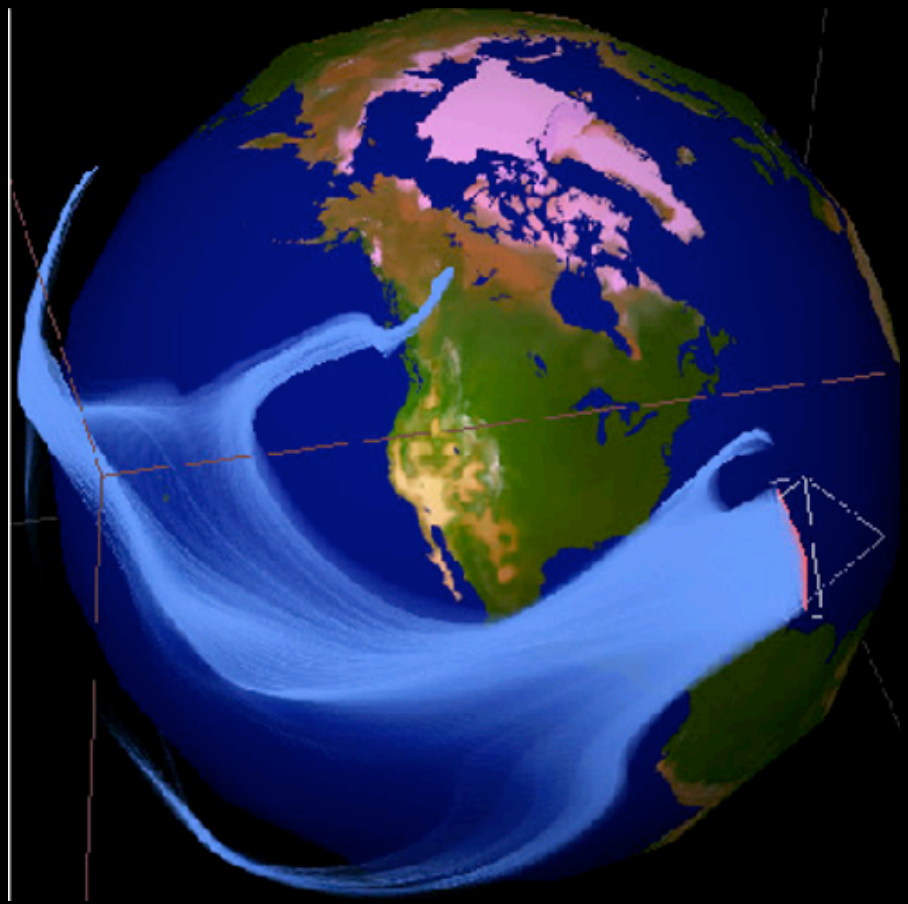
Square can be subdivided into a finer mesh.

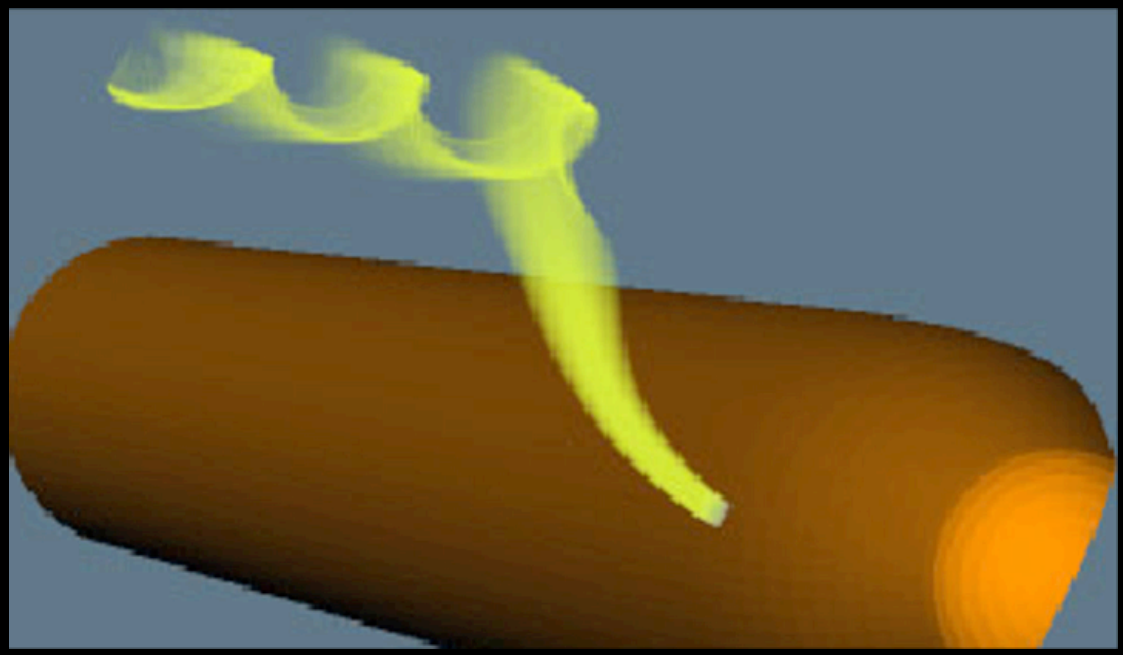
Like explicit stream surfaces, the volume is adaptively subdivided in areas of high divergence.

There is no merging.

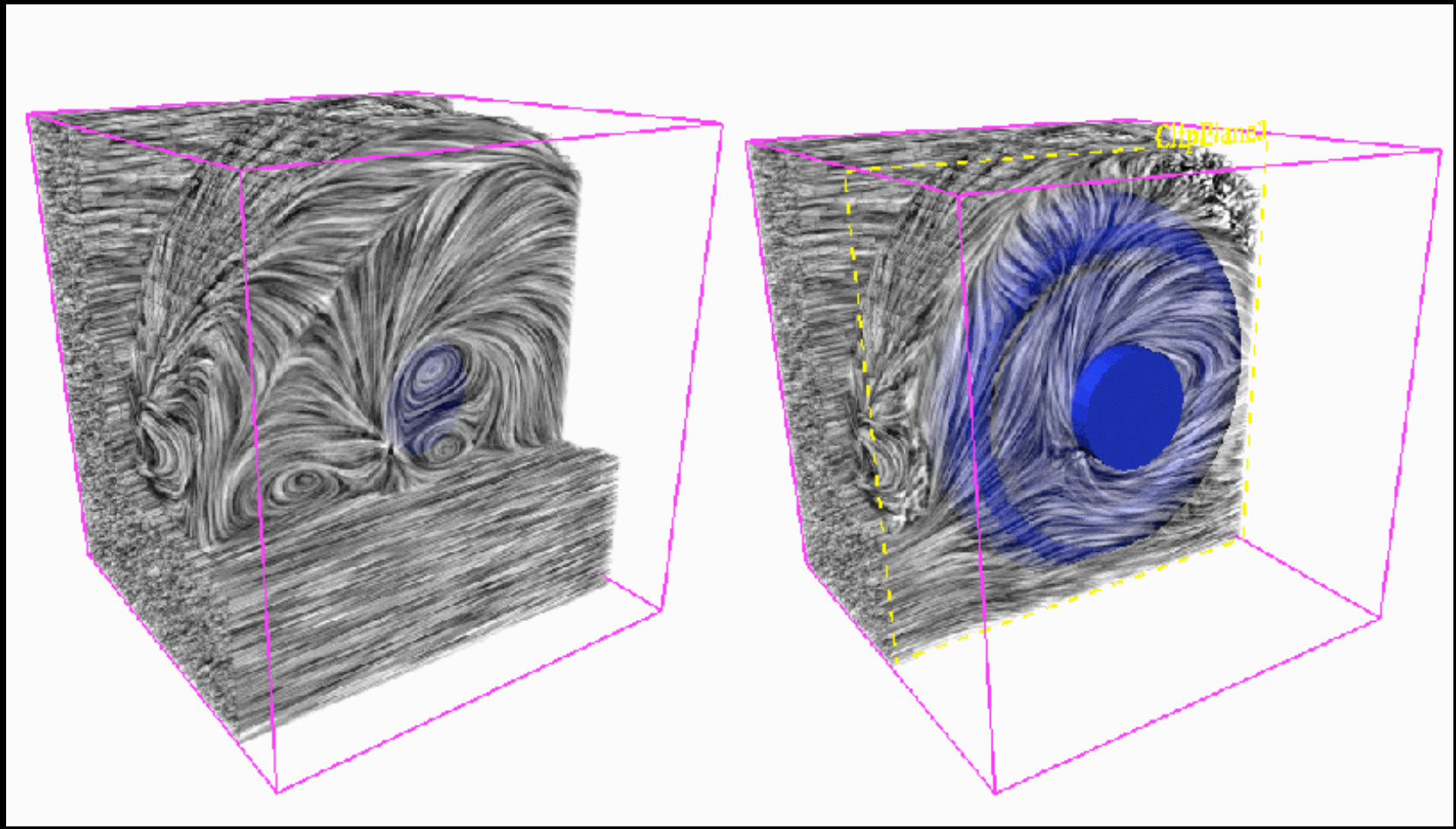


Flow Volumes



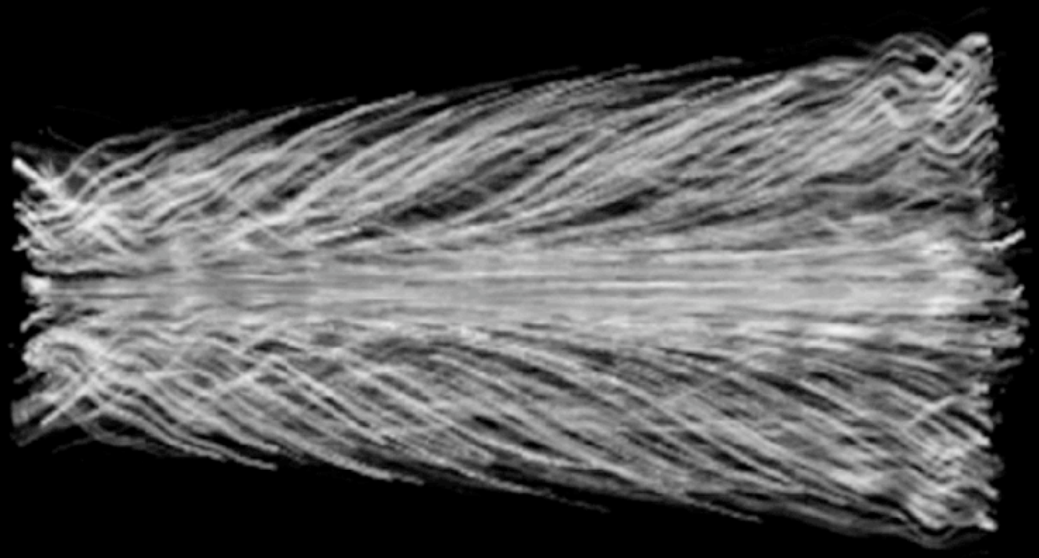


3D LIC



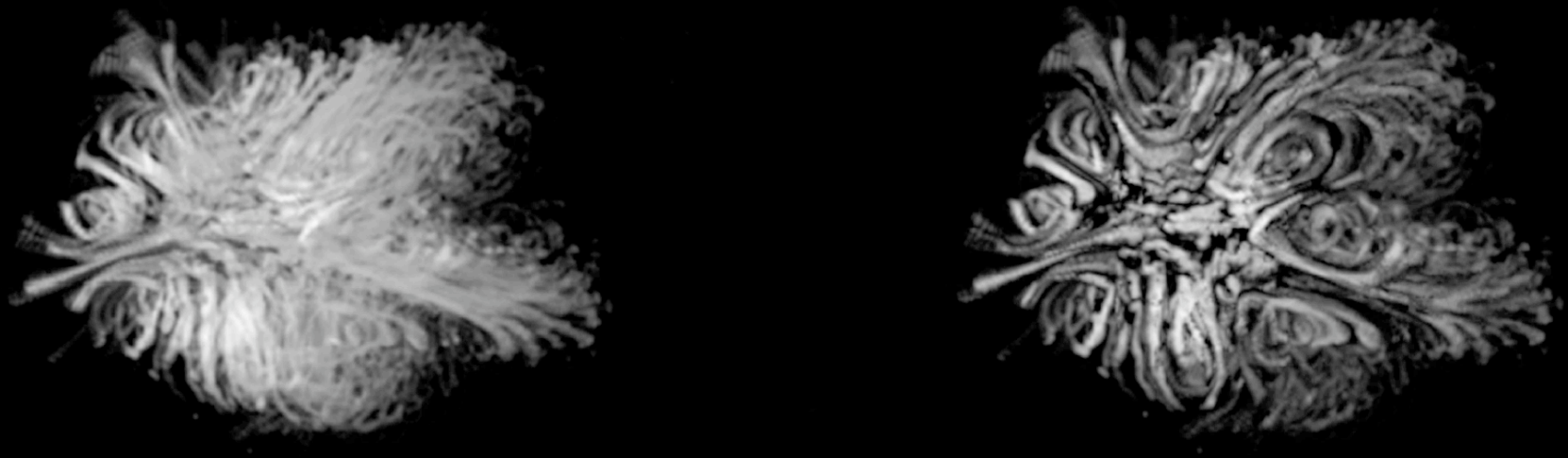
3D LIC

Shading is angle between flow and light directions



3D LIC

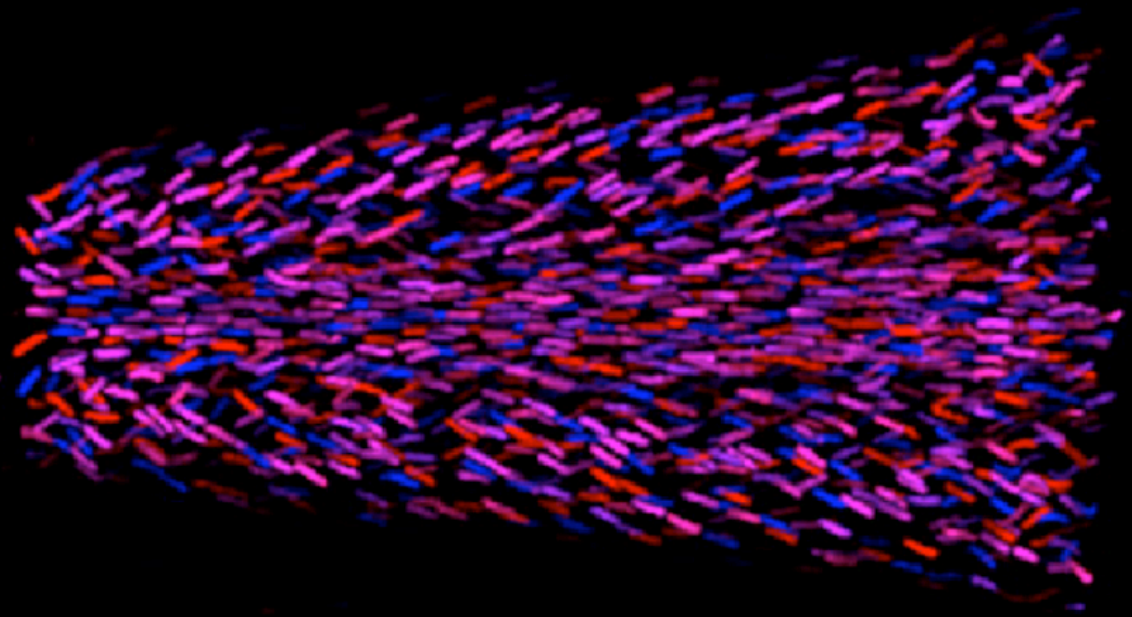
Use of halos (blocking area around lines)



Note: Improvement

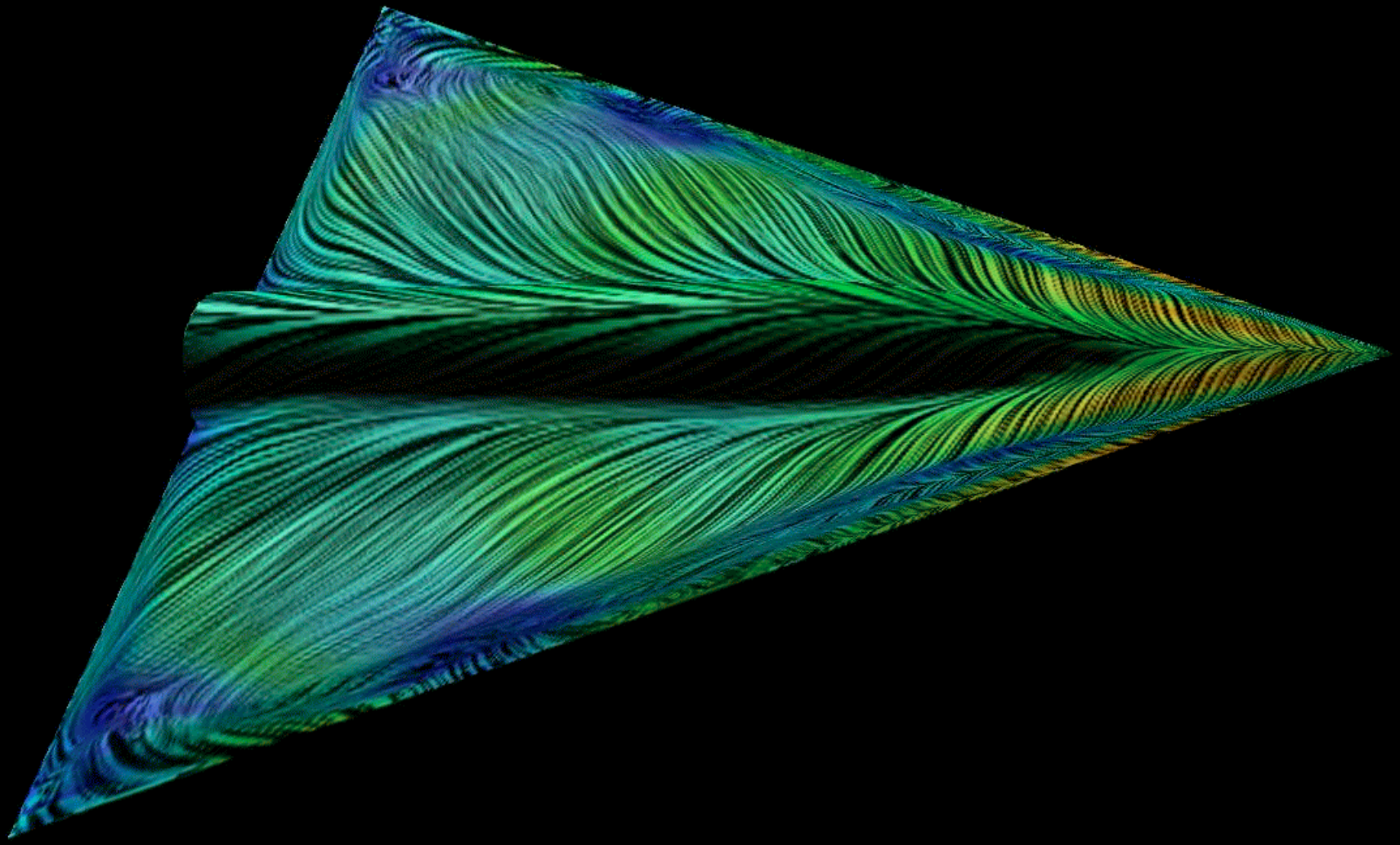
3D LIC

Use of halos doesn't always work!

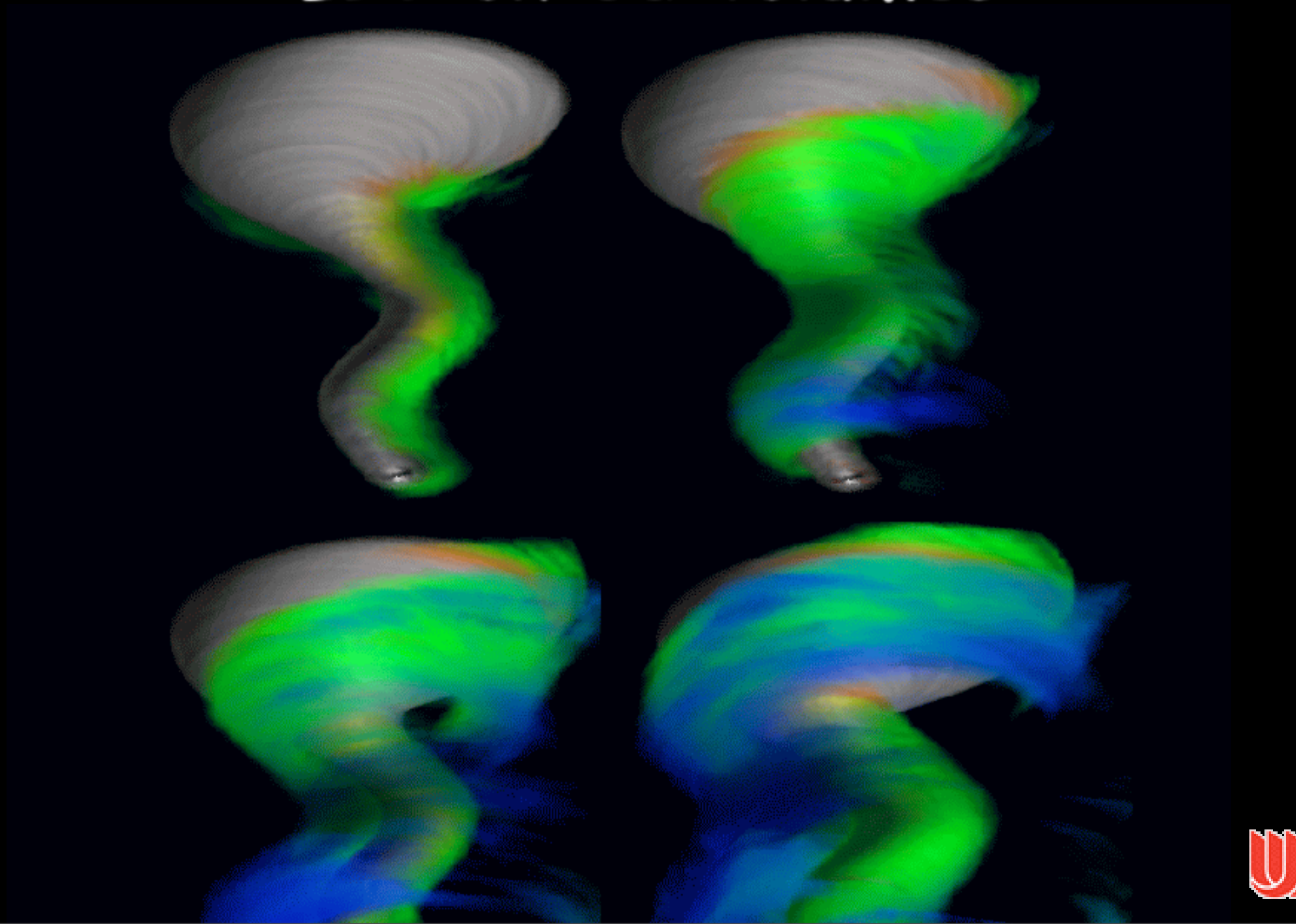


Note: Lack of perceived depth

LIC on 3D surfaces



LIC on 3d volumes



Illuminated Streamlines

Illuminated Streamlines