



Analysis of Fragmentation in Shock Physics Simulation

Ultrascale Visualization Workshop 2008

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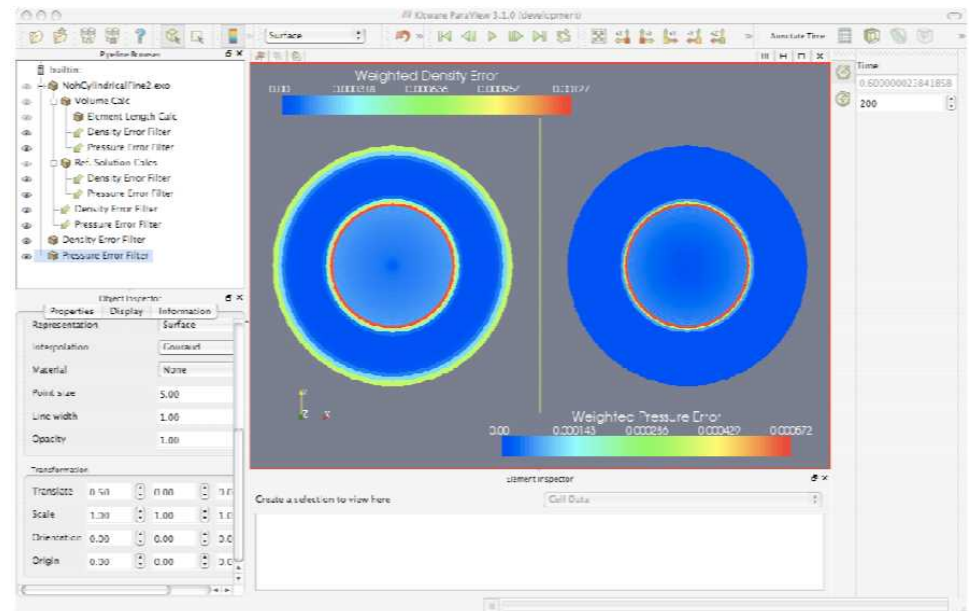
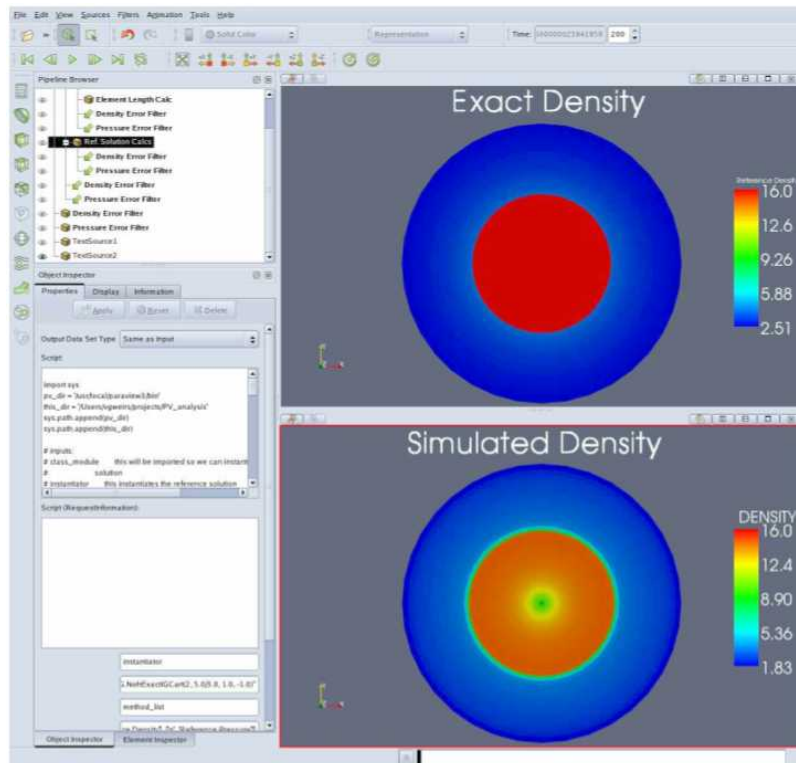
*An **experiment** is the partial knowledge of the full truth.*

*A **simulation** is the full knowledge of a partial truth.*

Verification and Validation (V&V) brings these together.

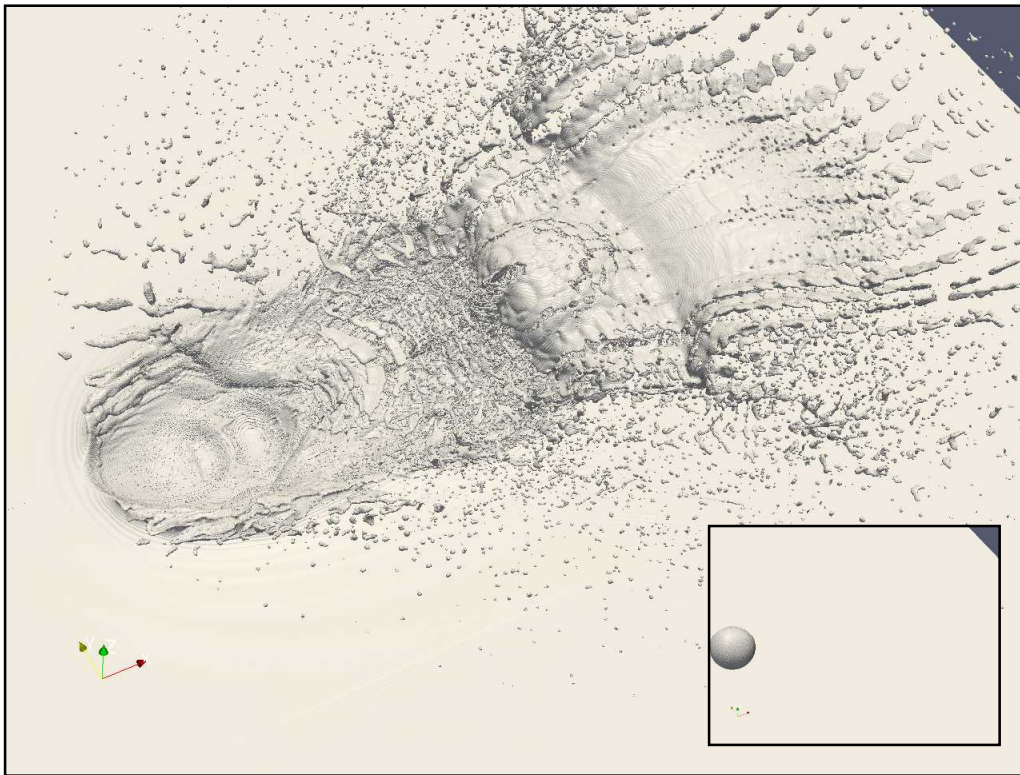
The V of V&V

- **Verification** compares simulations with known analytical solutions.

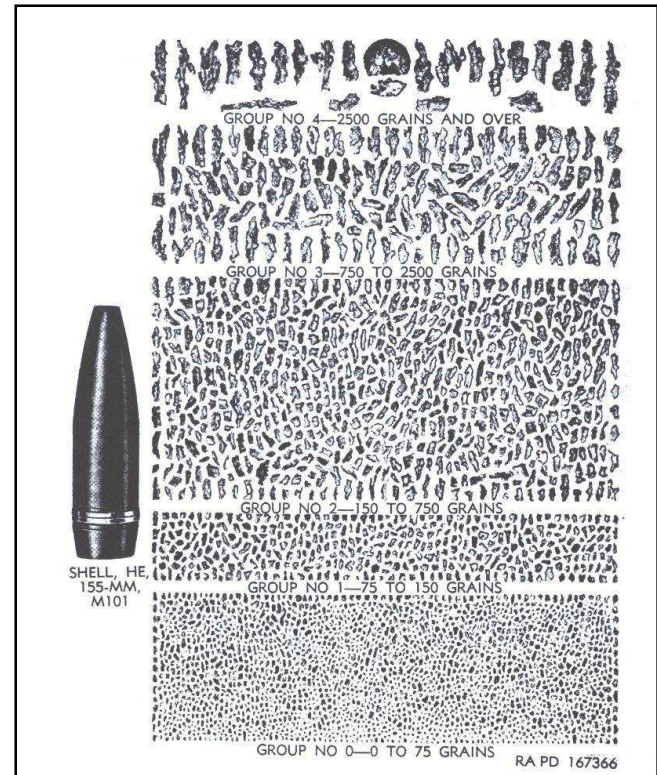


The Other V of V&V

- **Validation** compares simulations with experiments.

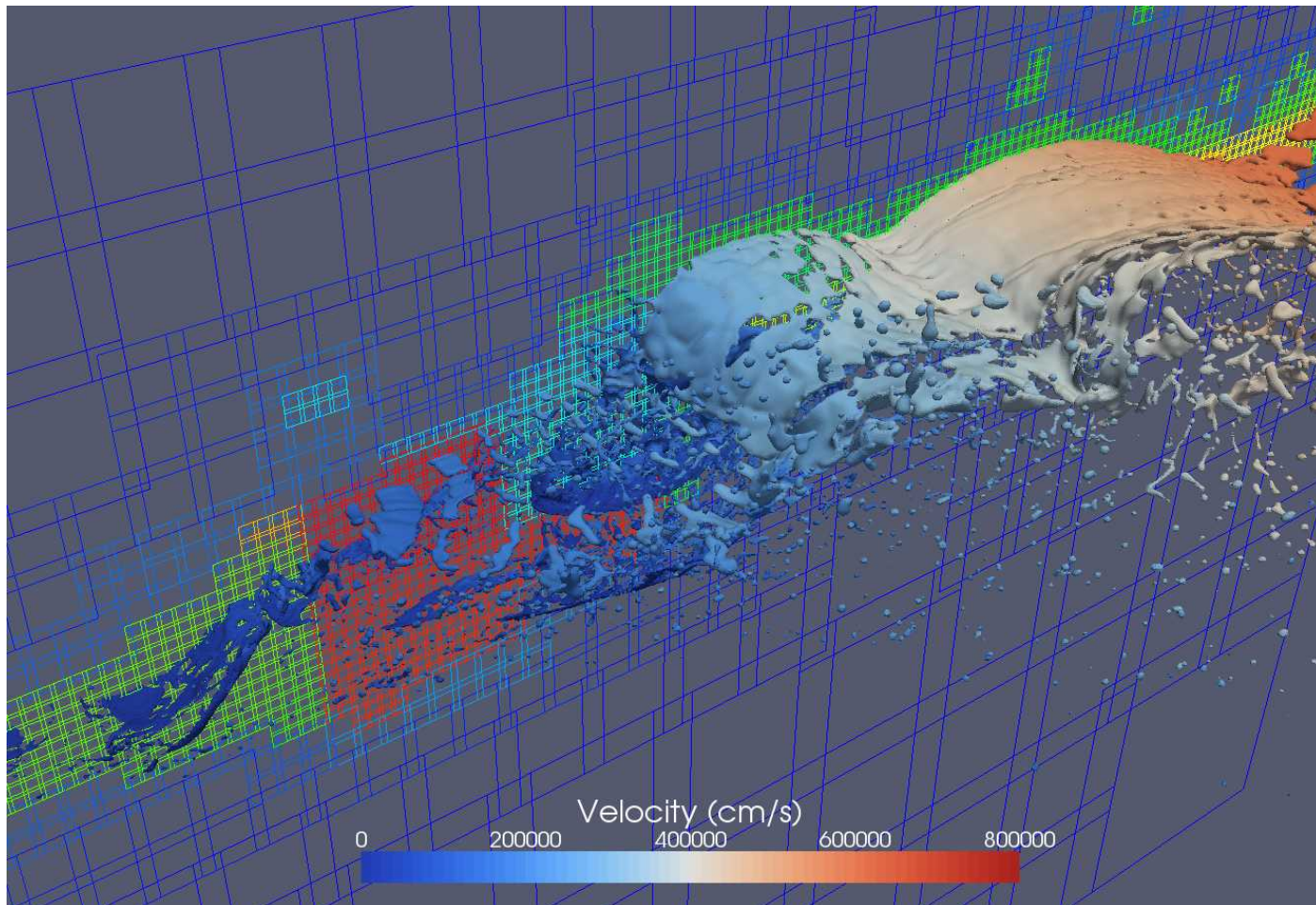


Simulation data near the end of the simulation, showing the complex distribution of fragments. Inset shows first frame of the simulation, in which a ball approaches a plate of the same material.



Test data, showing shell fragments grouped according to size.

Identifying Fragments





Step 1: Fragment Connectivity

0.2	0.3	0.0	0.2	0.3	0.2	0.4	0.1	0.0
0.4	0.4	0.1	0.3	0.5	0.4			
0.4	0.4	0.3	0.4	0.7	0.5	0.6	0.3	0.1
0.6	0.5	0.4	0.6	0.9	0.7			
0.8	0.7	0.7	1.0	0.9	0.8	0.7	0.5	0.2
1.0	1.0	1.0	0.9	0.7	0.6			



Step 1: Fragment Connectivity

0.2	0.3	0.0	0.2	0.3	0.2
0.4	0.4	0.1	0.3	0.5	0.4
0.4	0.4	0.3	0.4	0.7	0.5
0.6	0.5	0.4	0.6	0.9	0.7
0.8	0.7	0.7	1.0	0.9	0.8
1.0	1.0	1.0	0.9	0.7	0.6

0.4	0.1	0.0
0.6	0.3	0.1
0.7	0.5	0.2



Step 1: Fragment Connectivity

0.2	0.3	0.0	0.2	0.3	0.2	0.4
0.4	0.4	0.1	0.3	0.5	0.4	
0.4	0.4	0.3	0.4	0.7	0.5	0.6
0.6	0.5	0.4	0.6	0.9	0.7	
0.8	0.7	0.7	1.0	0.9	0.8	0.7
1.0	1.0	1.0	0.9	0.7	0.6	

0.2	0.4	0.1	0.0
0.4			
0.5	0.6	0.3	0.1
0.7			
0.8	0.7	0.5	0.2
0.6			



Step 1: Fragment Connectivity

0.2	0.3	0.0	0.2	0.3	0.2	0.4
0.4	0.4	0.1	0.3	0.5	0.4	
0.4	0.4	0.3	0.4	0.7	0.5	0.6
0.6	0.5	0.4	0.6	0.9	0.7	
0.8	0.7	0.7	1.0	0.9	0.8	0.7
1.0	1.0	1.0	0.9	0.7	0.6	

0.2	0.4	0.1	0.0
0.4			
0.5	0.6	0.3	0.1
0.7			
0.8	0.7	0.5	0.2
0.6			



Step 1: Fragment Connectivity

0.2	0.3	0.0	0.2	0.3	0.2	0.4
0.4	0.4	0.1	0.3	0.5	0.4	
0.4	0.4	0.3	0.4	0.7	0.5	0.6
0.6	0.5	0.4	0.6	0.9	0.7	
0.8	0.7	0.7	1.0	0.9	0.8	0.7
1.0	1.0	1.0	0.9	0.7	0.6	

0.2	0.4	0.1	0.0
0.4			
0.5	0.6	0.3	0.1
0.7			
0.8	0.7	0.5	0.2
0.6			



Step 1: Fragment Connectivity

0.2	0.3	0.0	0.2	0.3	0.2	0.4
0.4	0.4	0.1	0.3	0.5	0.4	
0.4	0.4	0.3	0.4	0.7	0.5	0.6
0.6	0.5	0.4	0.6	0.9	0.7	
0.8	0.7	0.7	1.0	0.9	0.8	0.7
1.0	1.0	1.0	0.9	0.7	0.6	

0.2	0.4	0.1	0.0
0.4			
0.5	0.6	0.3	0.1
0.7			
0.8	0.7	0.5	0.2
0.6			



Step 1: Fragment Connectivity

0.2	0.3	0.0	0.2	0.3	0.2	0.4
0.4	0.4	0.1	0.3	0.5	0.4	
0.4	0.4	0.3	0.4	0.7	0.5	0.6
0.6	0.5	0.4	0.6	0.9	0.7	
0.8	0.7	0.7	1.0	0.9	0.8	0.7
1.0	1.0	1.0	0.9	0.7	0.6	

0.2	0.4	0.1	0.0
0.4			
0.5	0.6	0.3	0.1
0.7			
0.8	0.7	0.5	0.2
0.6			



Step 1: Fragment Connectivity

0.2	0.3	0.0	0.2	0.3	0.2	0.4
0.4	0.4	0.1	0.3	0.5	0.4	
0.4	0.4	0.3	0.4	0.7	0.5	0.6
0.6	0.5	0.4	0.6	0.9	0.7	
0.8	0.7	0.7	1.0	0.9	0.8	0.7
1.0	1.0	1.0	0.9	0.7	0.6	

0.2	0.4	0.1	0.0
0.4			
0.5	0.6	0.3	0.1
0.7			
0.8	0.7	0.5	0.2
0.6			



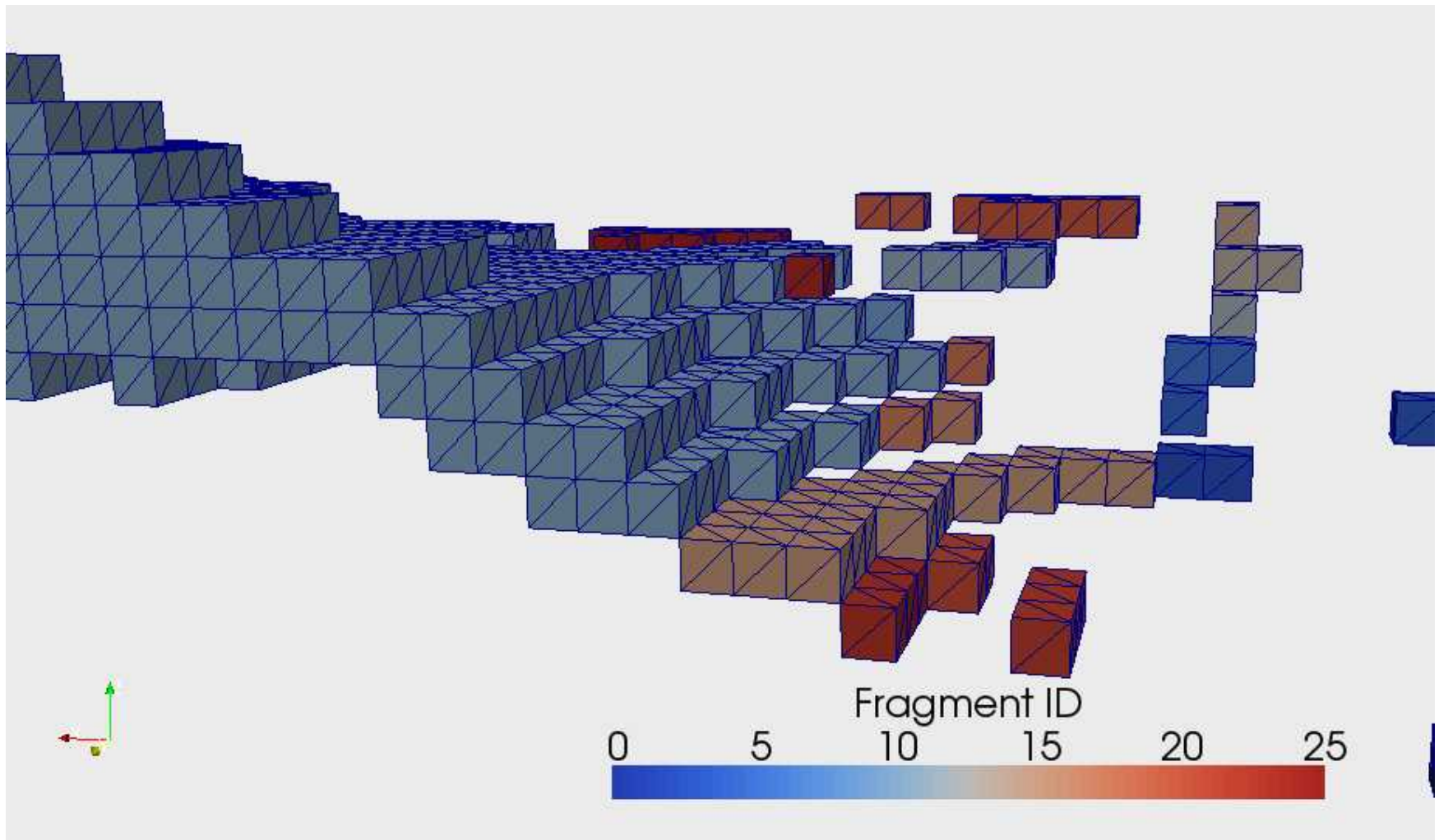
Step 1: Fragment Connectivity

0.2	0.3	0.0	0.2	0.3	0.2	0.4
0.4	0.4	0.1	0.3	0.5	0.4	
0.4	0.4	0.3	0.4	0.7	0.5	0.6
0.6	0.5	0.4	0.6	0.9	0.7	
0.8	0.7	0.7	1.0	0.9	0.8	0.7
1.0	1.0	1.0	0.9	0.7	0.6	

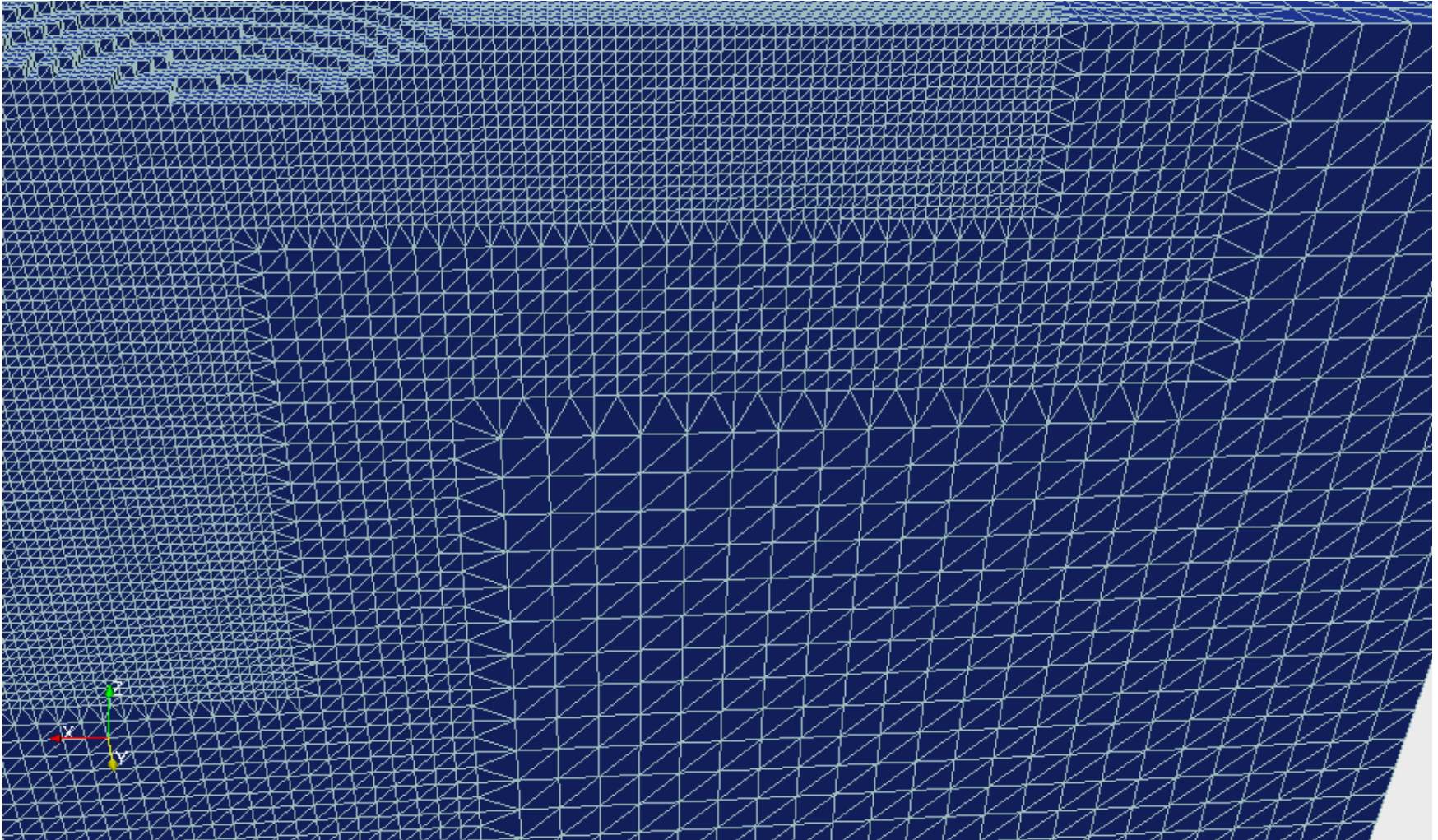
0.2	0.4	0.1	0.0
0.4			
0.5	0.6	0.3	0.1
0.7			
0.8	0.7	0.5	0.2
0.6			



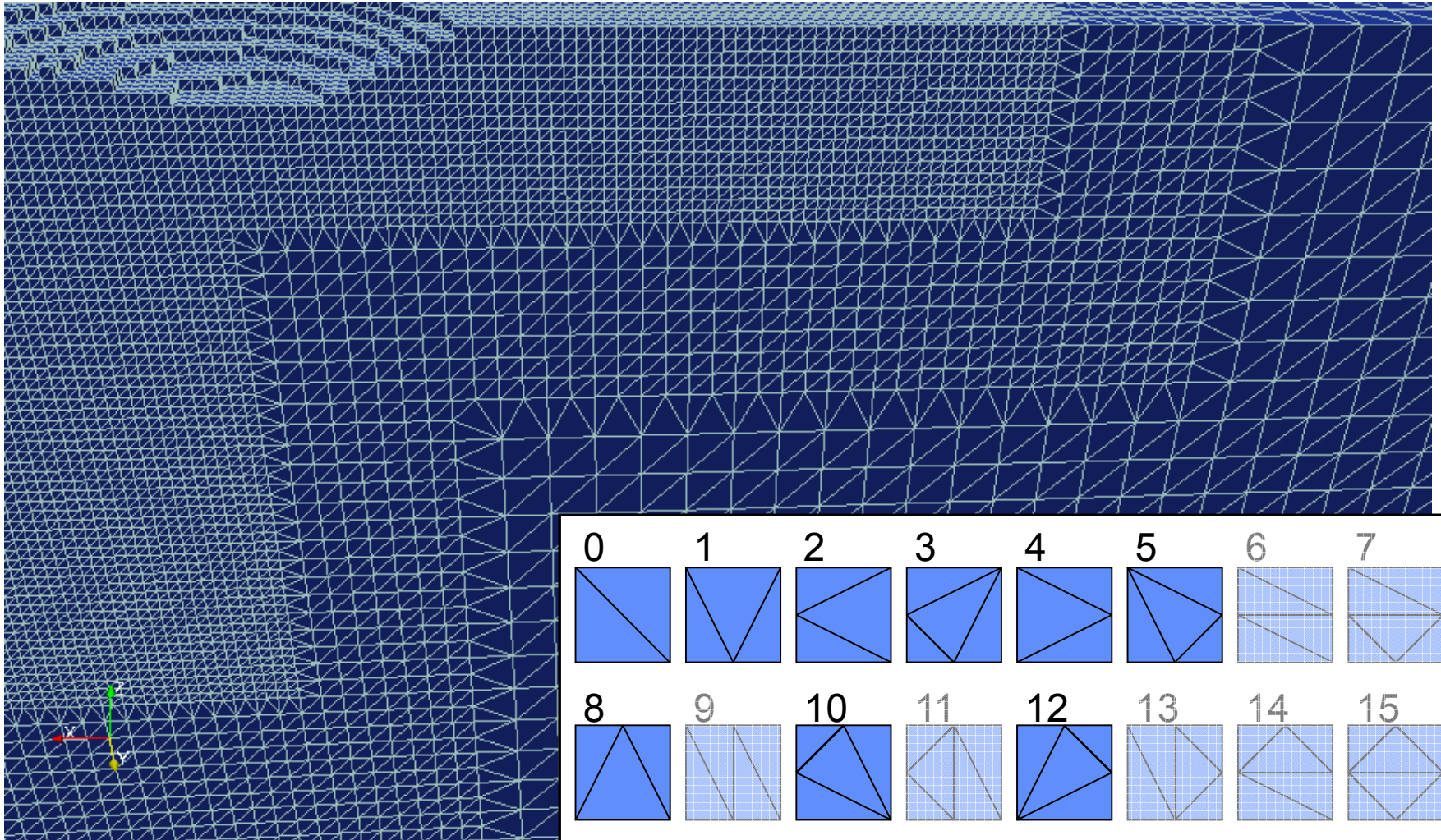
Step 2: Fragment Surfaces



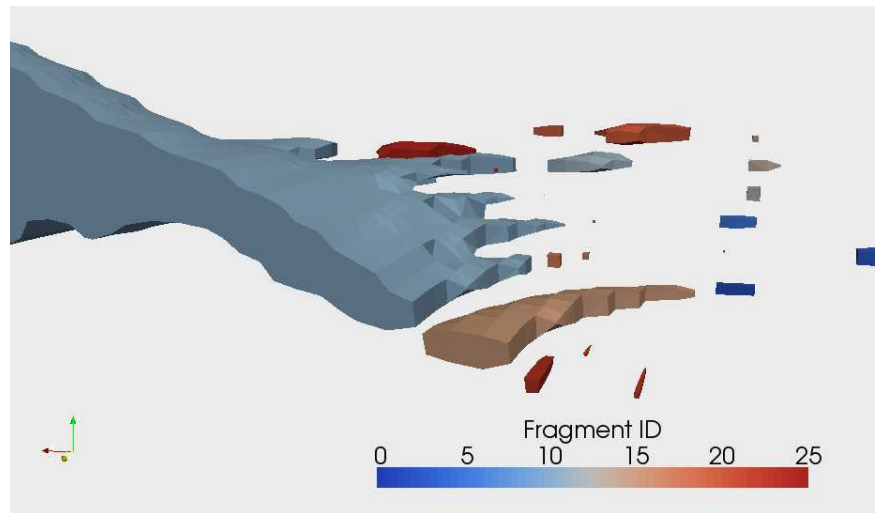
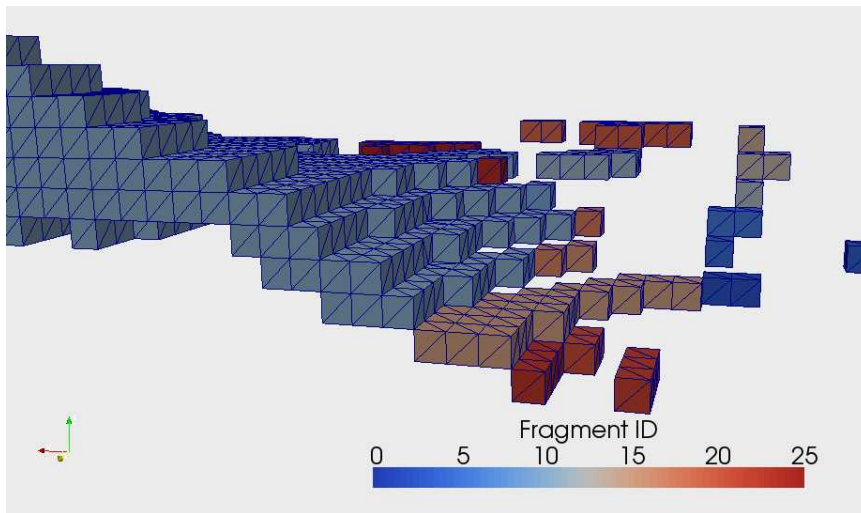
Step 2: Fragment Surfaces



Step 2: Fragment Surfaces



Step 3: Smooth Surfaces



Step 4: Extract Field Quantities

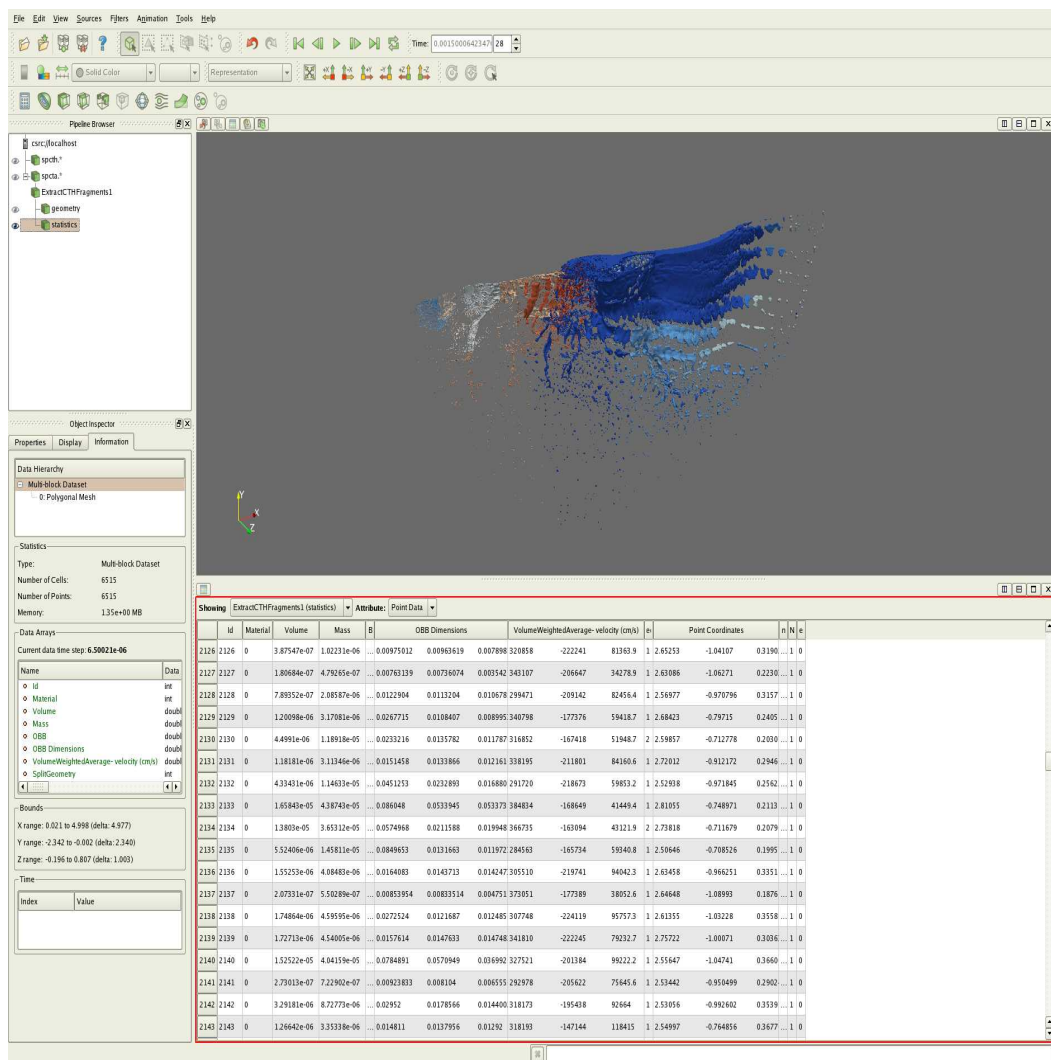
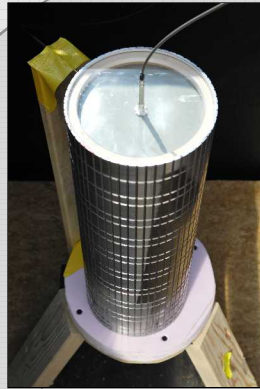


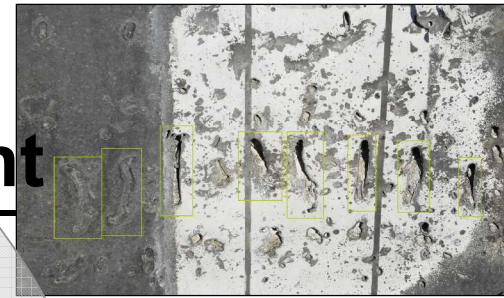
Diagram of the Experiment



Test article



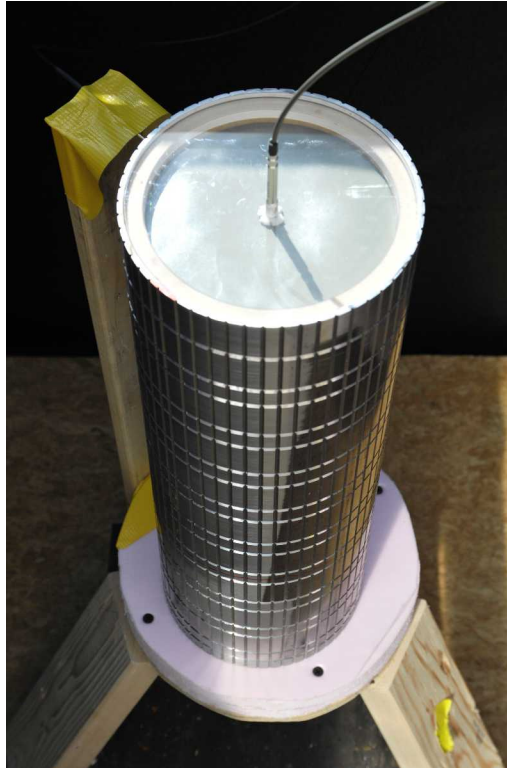
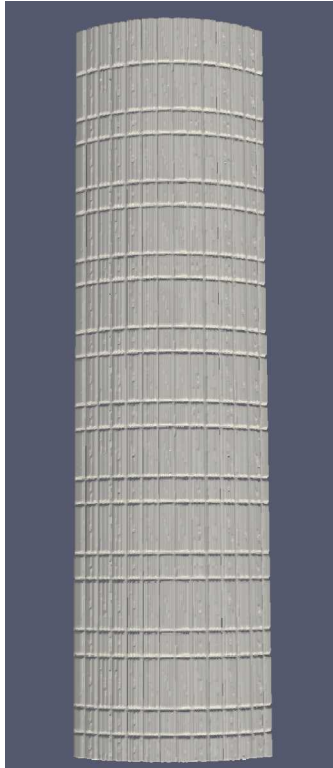
Fragments



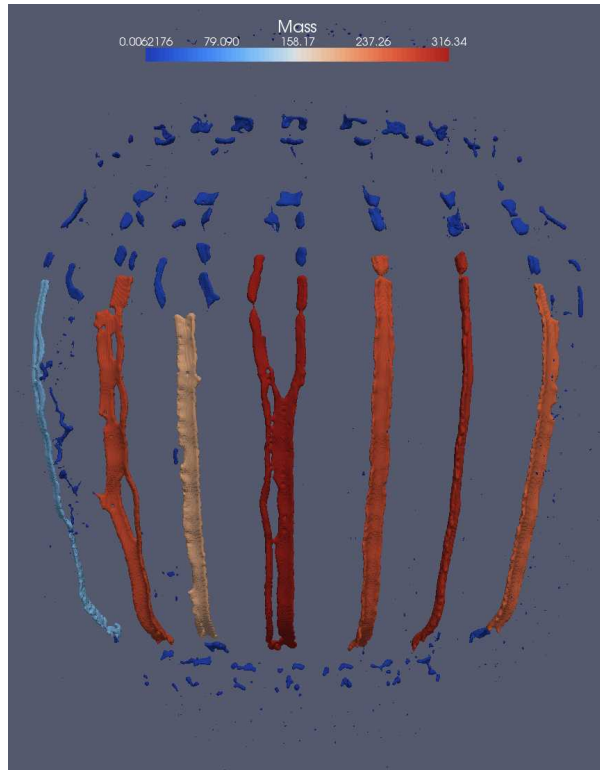
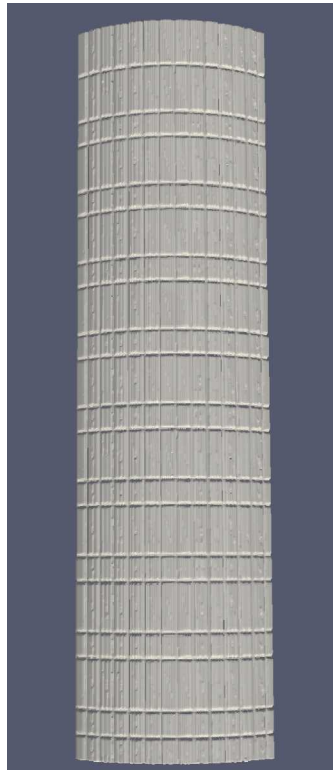
Witness
plate



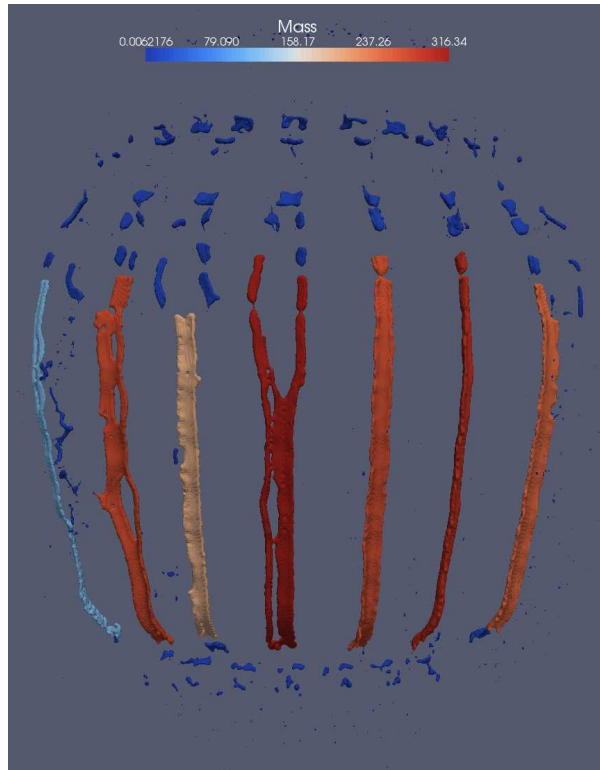
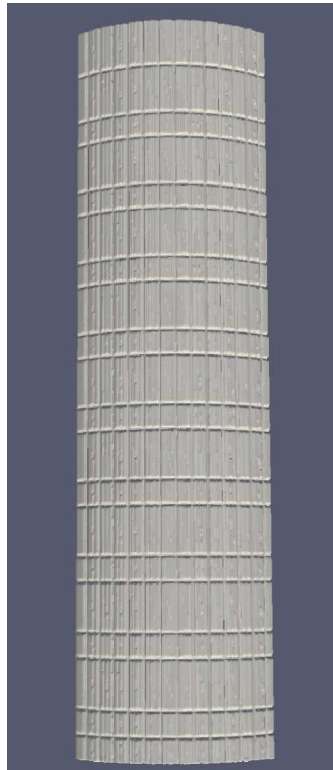
Corresponding Simulation



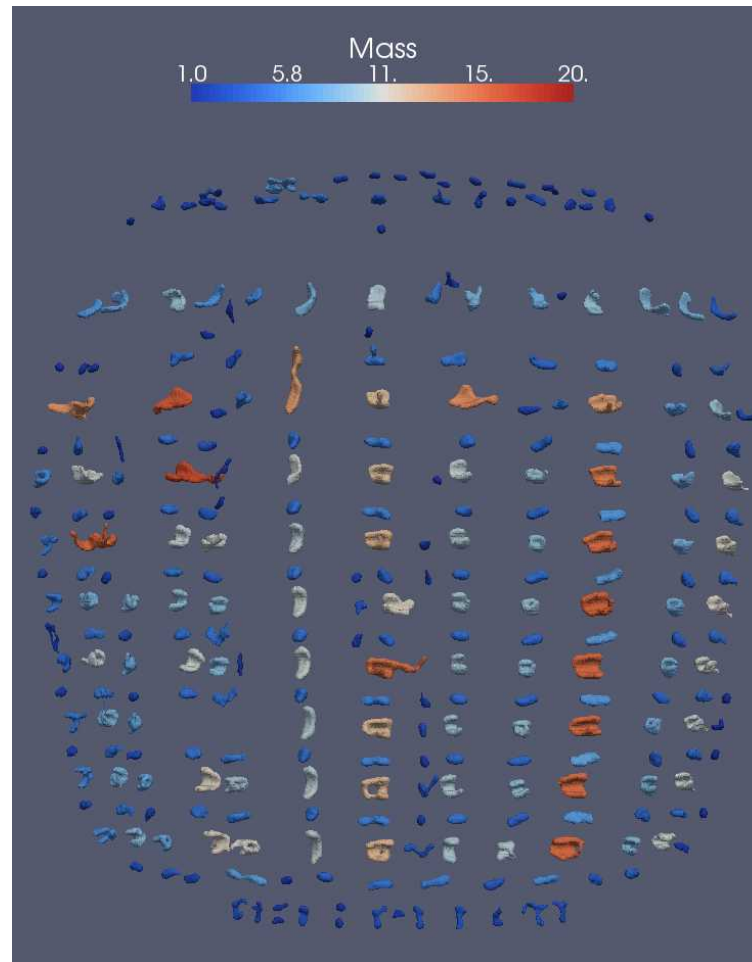
Corresponding Simulation



Corresponding Simulation



Redesigning the Shell

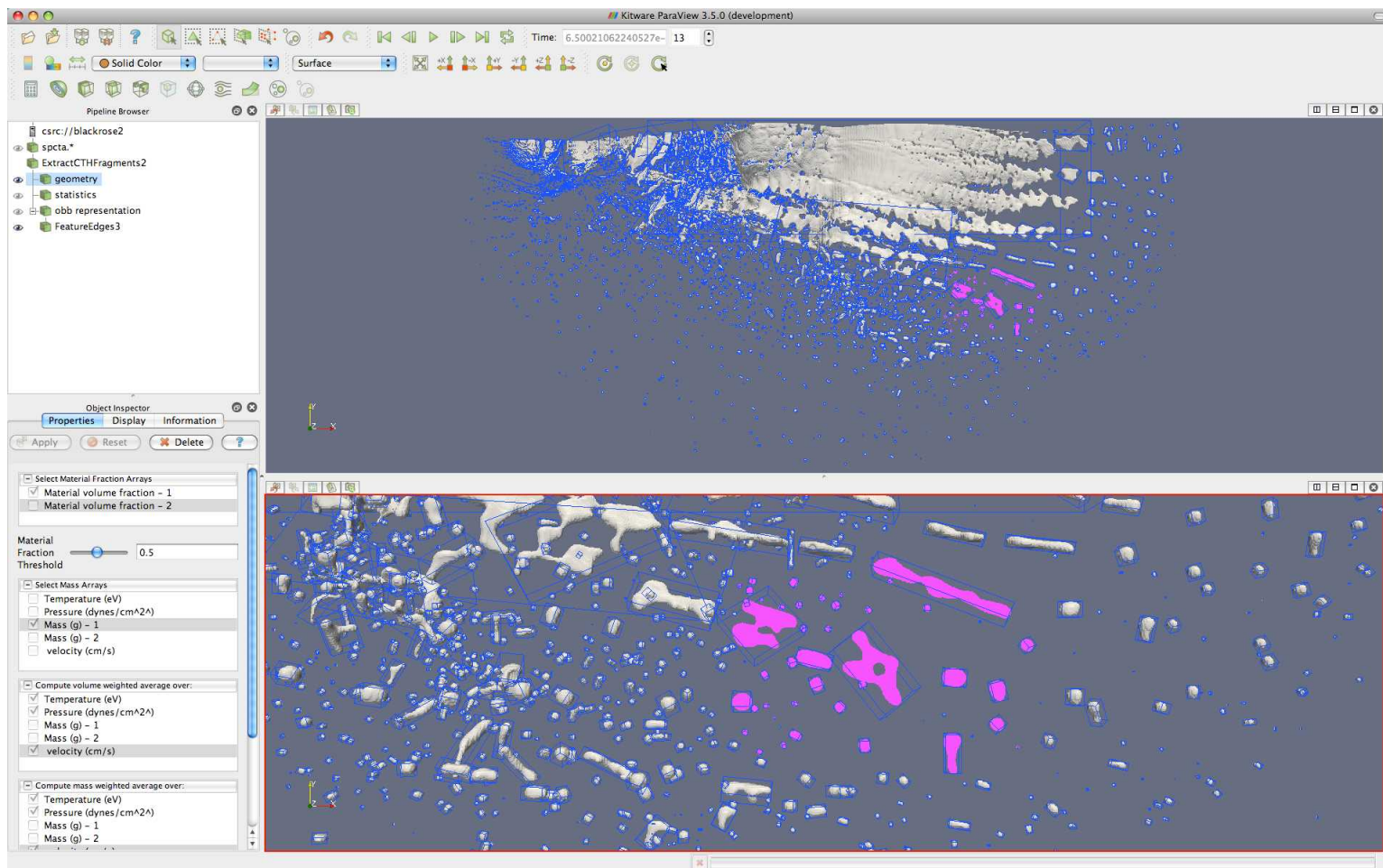


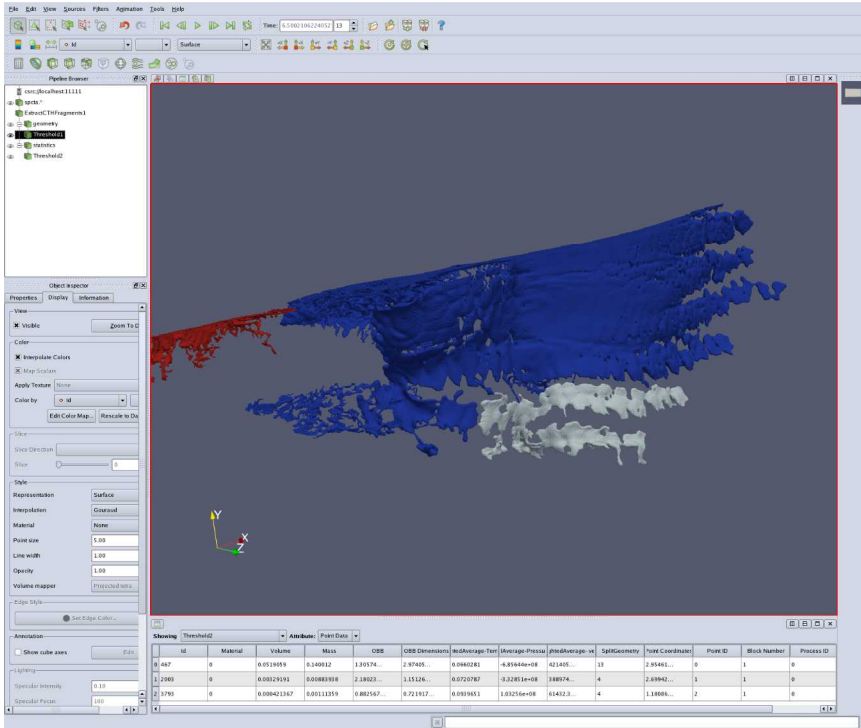


Further Analysis of Fragments

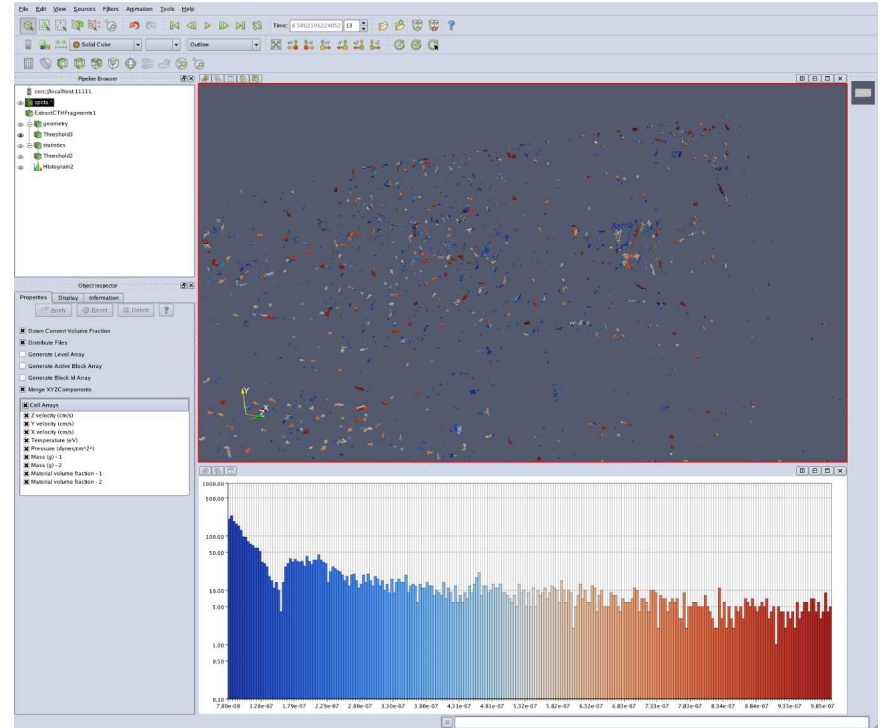
QuickTime™ and a
decompressor
are needed to see this picture.

Drilling Down to Fragment Data



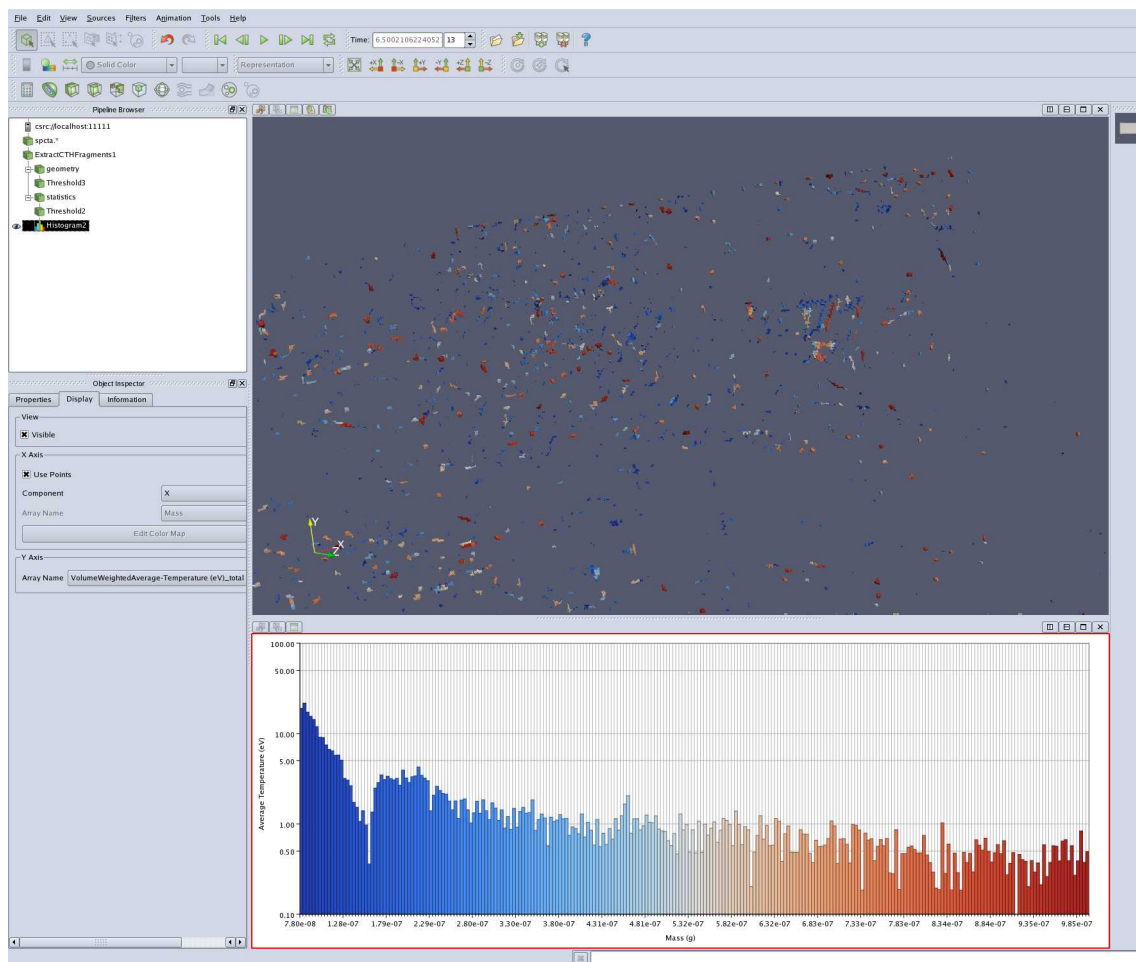


The three heaviest fragments.

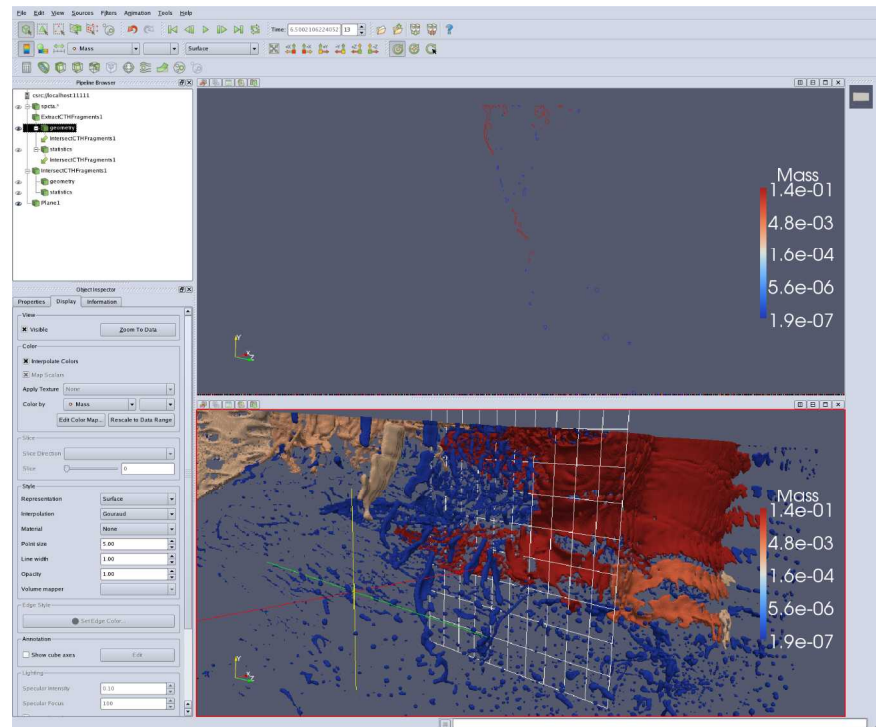
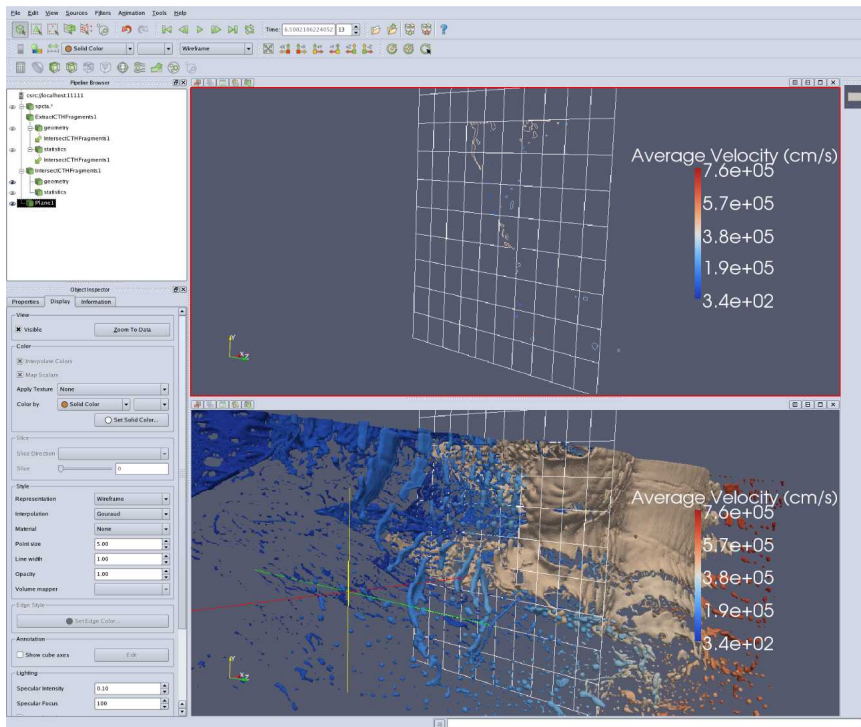


The lightest fragments (with mass between 0.01 and 1 micrograms).

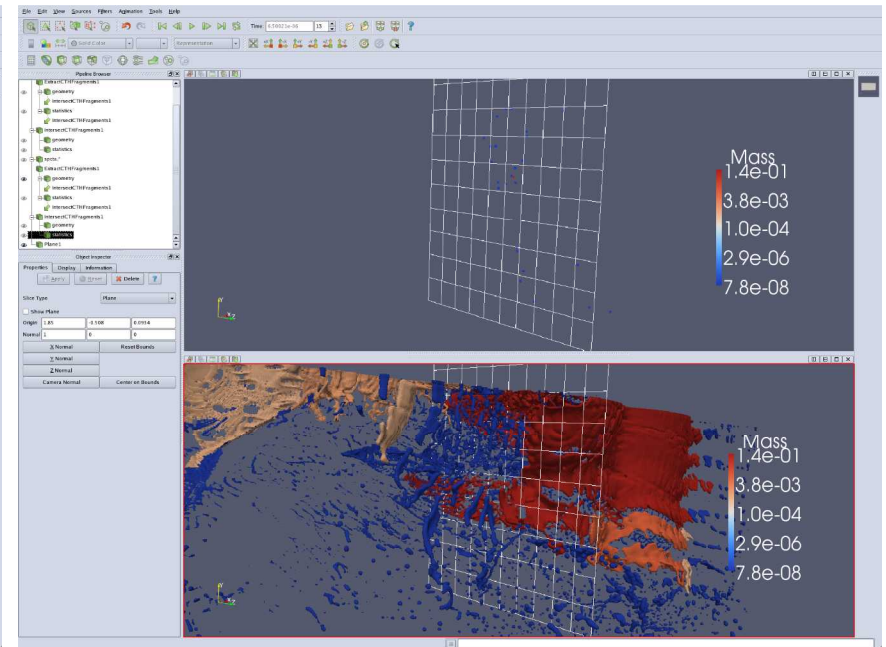
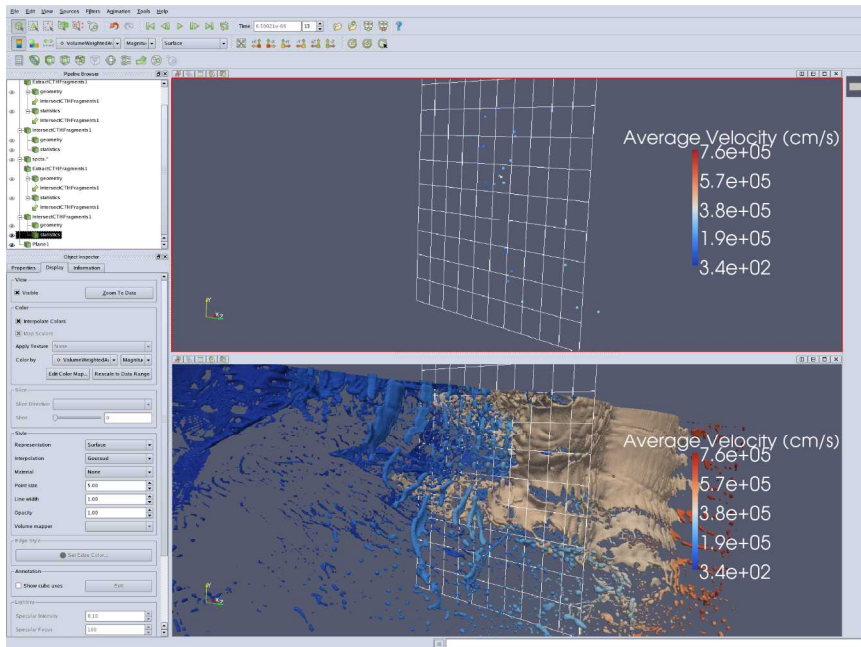
Average Field Values for Fragment Distributions



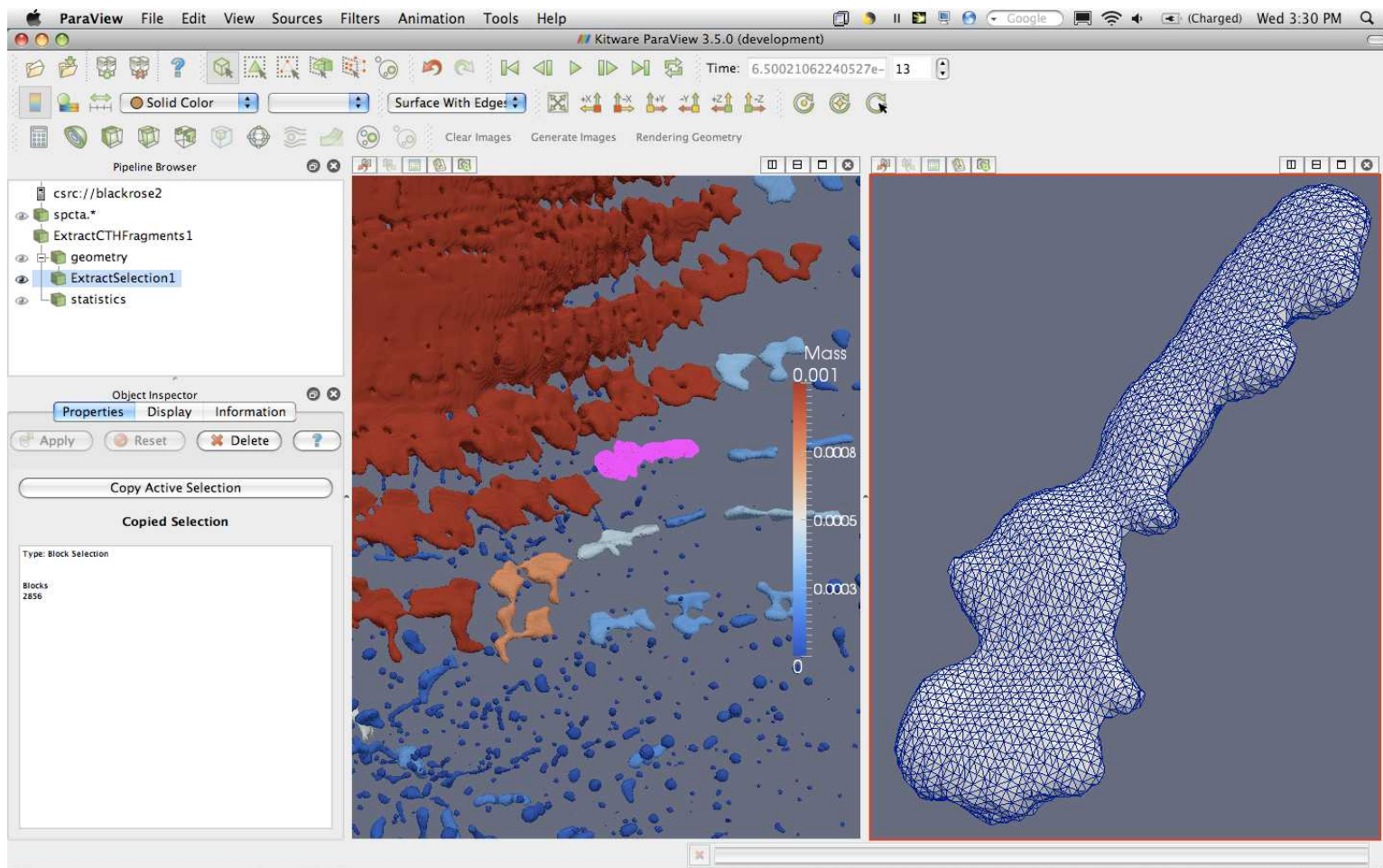
Intersection Queries



Intersection Queries



Current Work: Fragment Remeshing





Current Work: In-Situ Processing

QuickTime™ and a
Motion JPEG OpenDML decompressor
are needed to see this picture.