Feature Extraction & Tracking: What next?

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http://www.caip.rutgers.edu/vizlab.html

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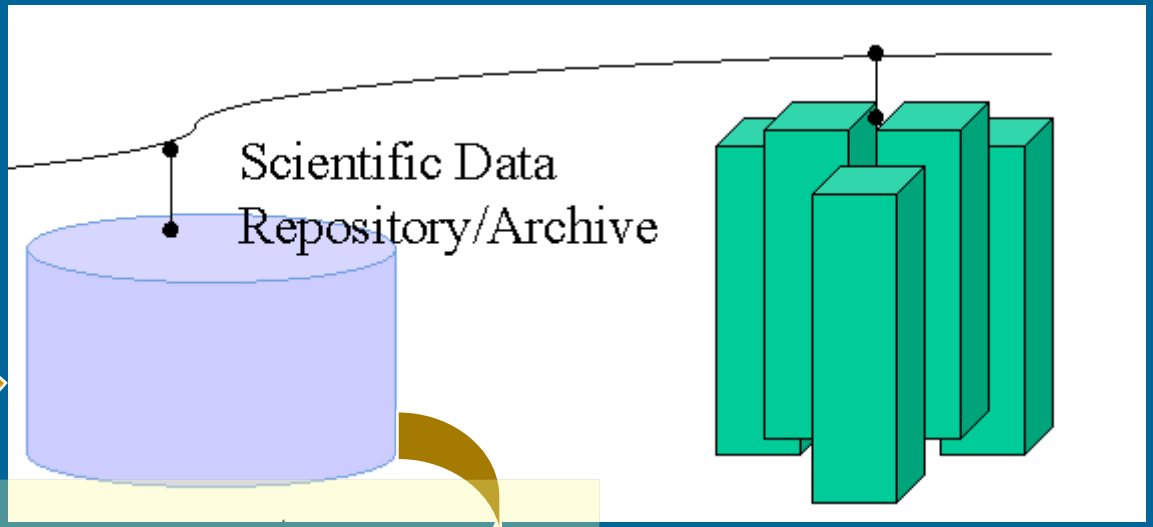
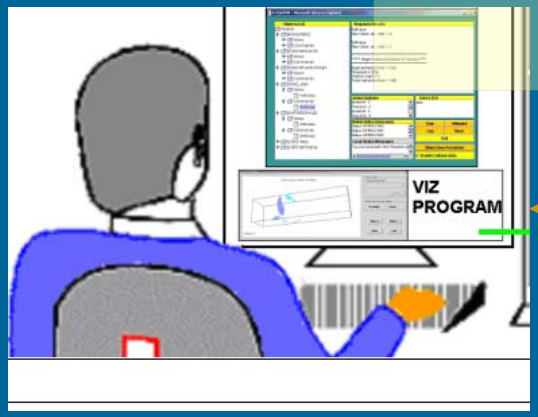
Space/Time reduction

As the datasets become larger and larger, it becomes physically impossible to do in-depth discovery of all of the data. Filtering techniques are necessary to help the scientist focus on regions of interest in the ***space/time*** domain.

Data Reduction



Filter/pre-process/reduce



visualization

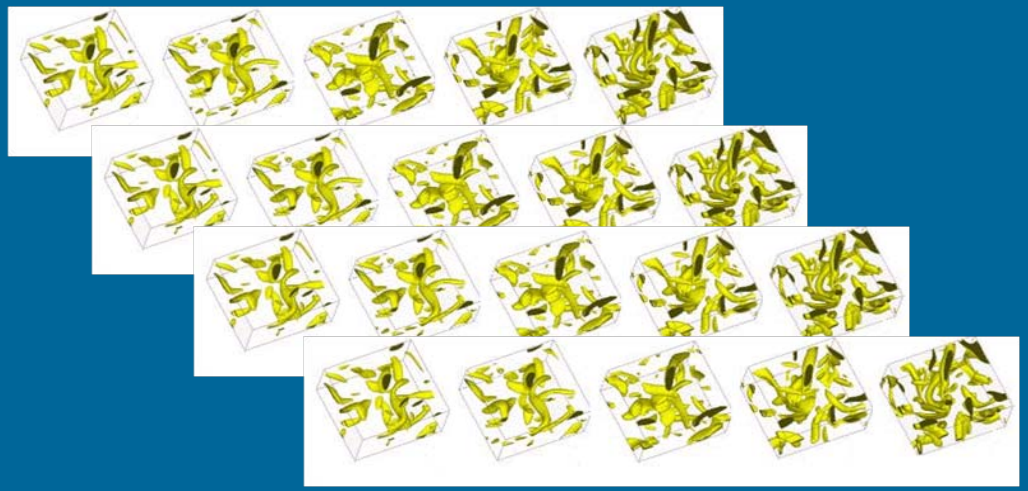
Effective Filtering

To Create *Effective Filtering* + *Visualizations* of Massive $3D^{+}$ Time Varying Simulation Data

➔

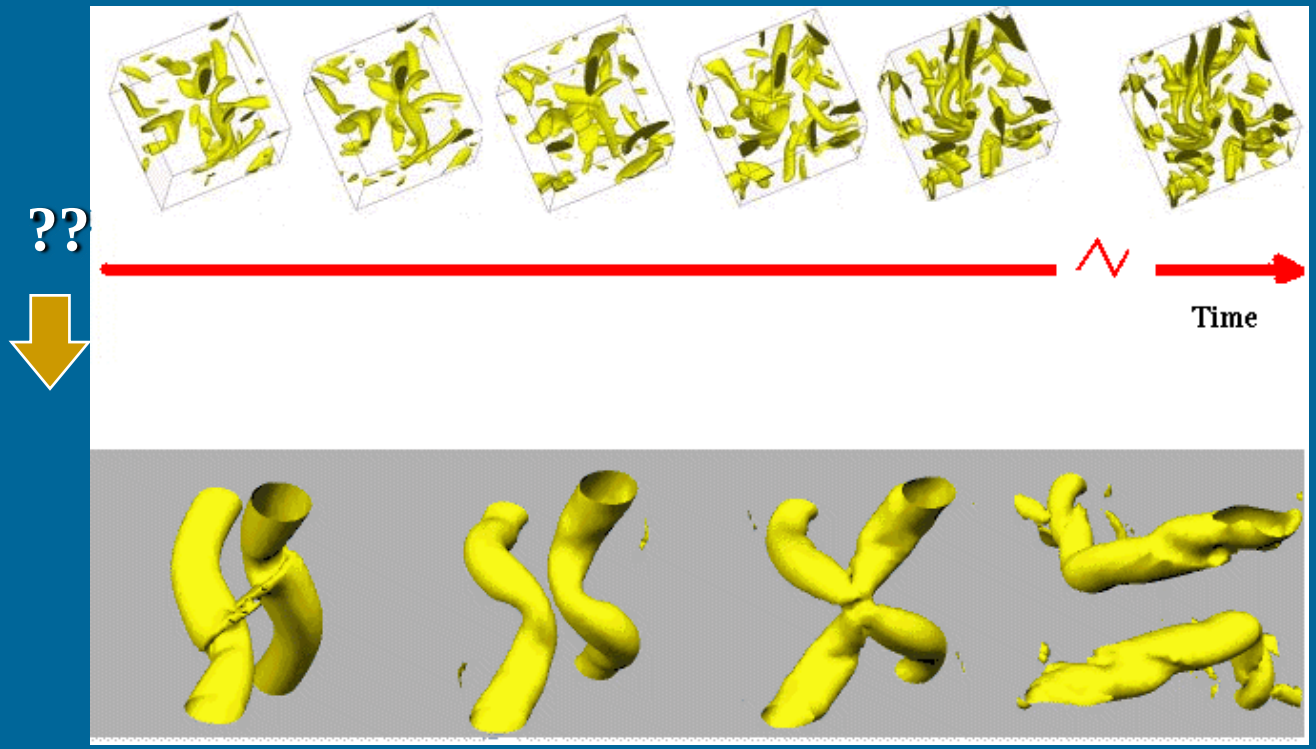
Feature Extraction & Tracking

Motivation



terabytes – very difficult to look through all of them – need a better way to search

Example-3D Event Querying



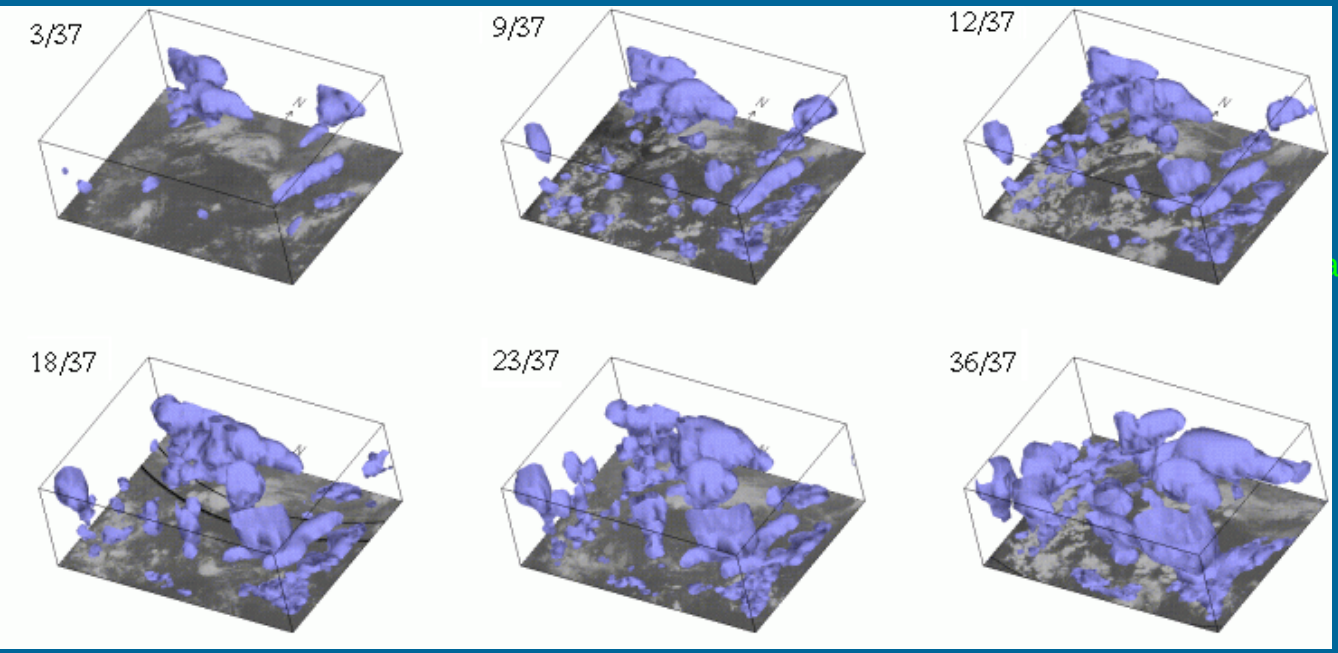
Vortex Reconnection

- Automatically find interesting events
- Follow Topological changes
- Classify events
- Search events

What is tracking?

- Following “features” over time
- “Features” can be anything --- defined as coherent blobs/objects meeting certain conditions

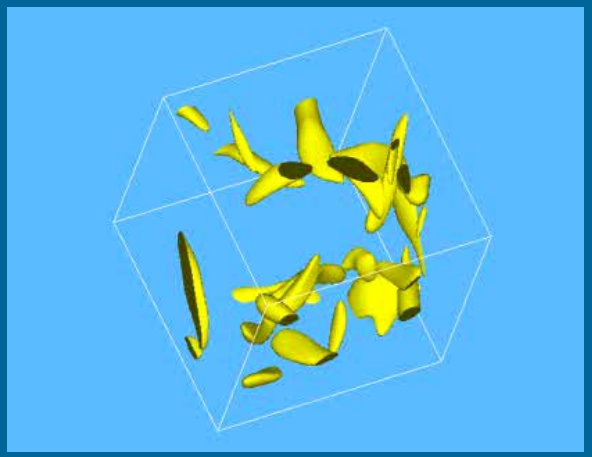
Weather Simulation



courtesy of Dr. YanChing Zhang at EPA

Isosurface of Cloud Water at threshold =0.00029

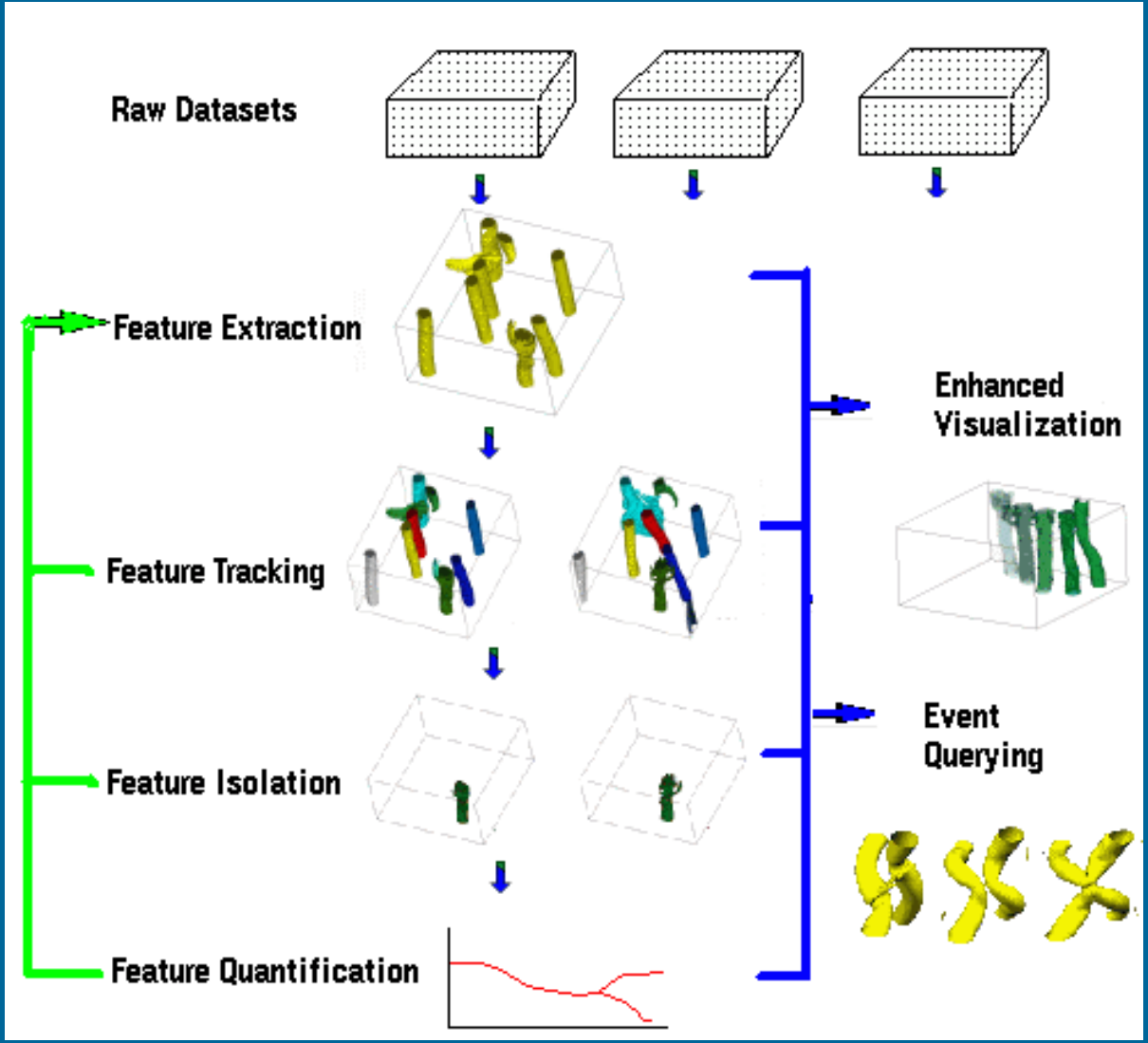
Pseudo-spectral Simulation.
Isosurface of vorticity magnitude at 48% of maximum
128^3, 100 timestepsn (shown)



Difficulties:

- Size – too much data
- Clutter (Visual)
- Quantification: measurements
- Querying capabilities:
  - How many regions are there?
  - Where are the big regions?
  - Is “XXXX” present?
  - How does this compare to a different simulation?
- Classification: store in a database

Feature-based Process Model



Major Components

- Feature Extraction
  - Define the features of interest. Domain dependent. Pre-defined or interactive.
- Feature Tracking
  - Automatically correlate extracted regions from one dataset to the next
- Quantification / Measurements for extraction & tracking.

--> BETTER VISUALIZATION

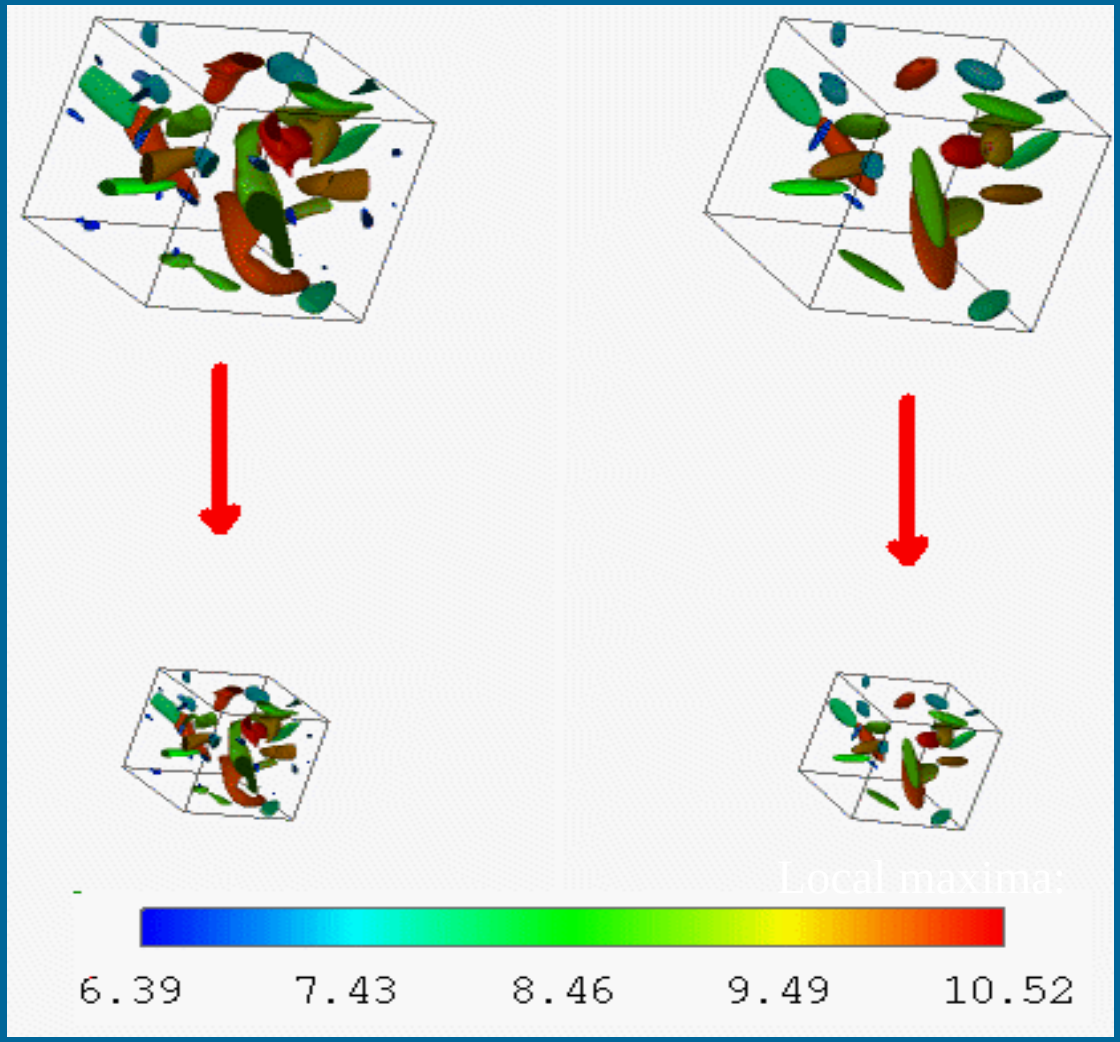
Features

- Basic definition
  - Regions of interest consisting of connected nodes satisfying some criteria (e.g. threshold interval, topological specification)
- Each domain has its own definition
  - Volume intervals [G95]
  - Segmentation [S95]
  - Selective Visualization [W95]
  - Domain specific: Shock waves, Vortex Cores, Eddies, Medical ...

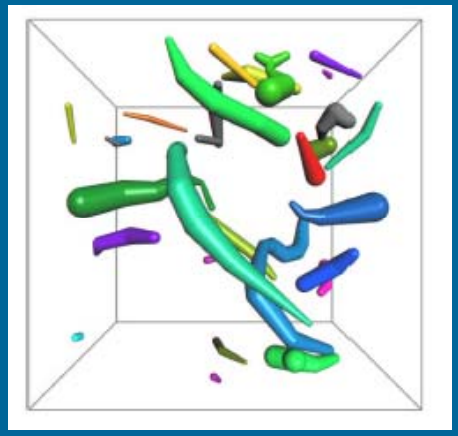
Feature Abstraction

- Abstract feature using a “reduced” representation object
- Compression of geometry
- Encapsulation of idea --- non-photorealistic rendering
- Reduced modeling

Abstraction: Data Reduction



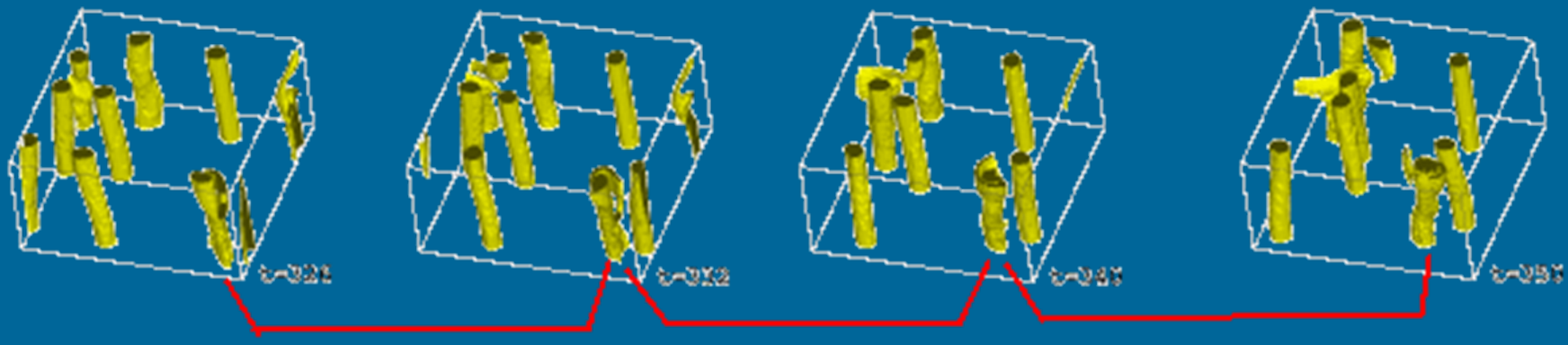
Abstraction using ellipsoids



Abstraction using skeletons

Feature Tracking

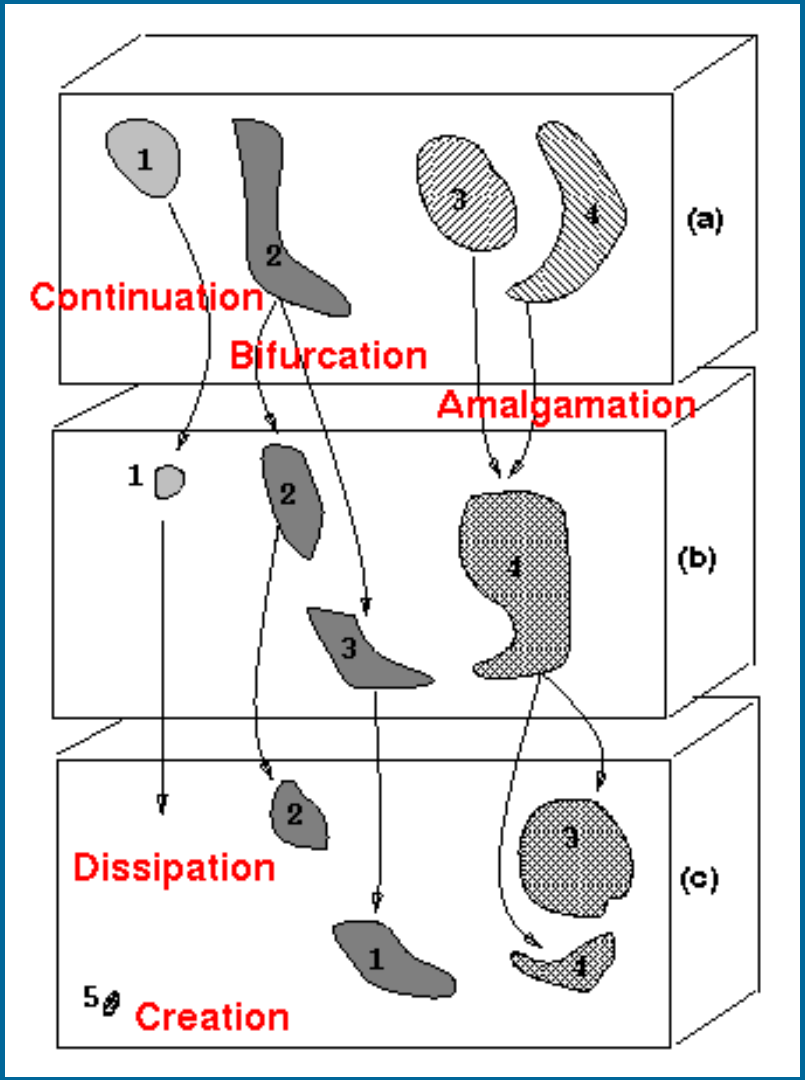
- Automatically correlate extracted regions from one dataset to the next



Assumption:
Sufficient Sampling Frequency such that corresponding features overlap in space.

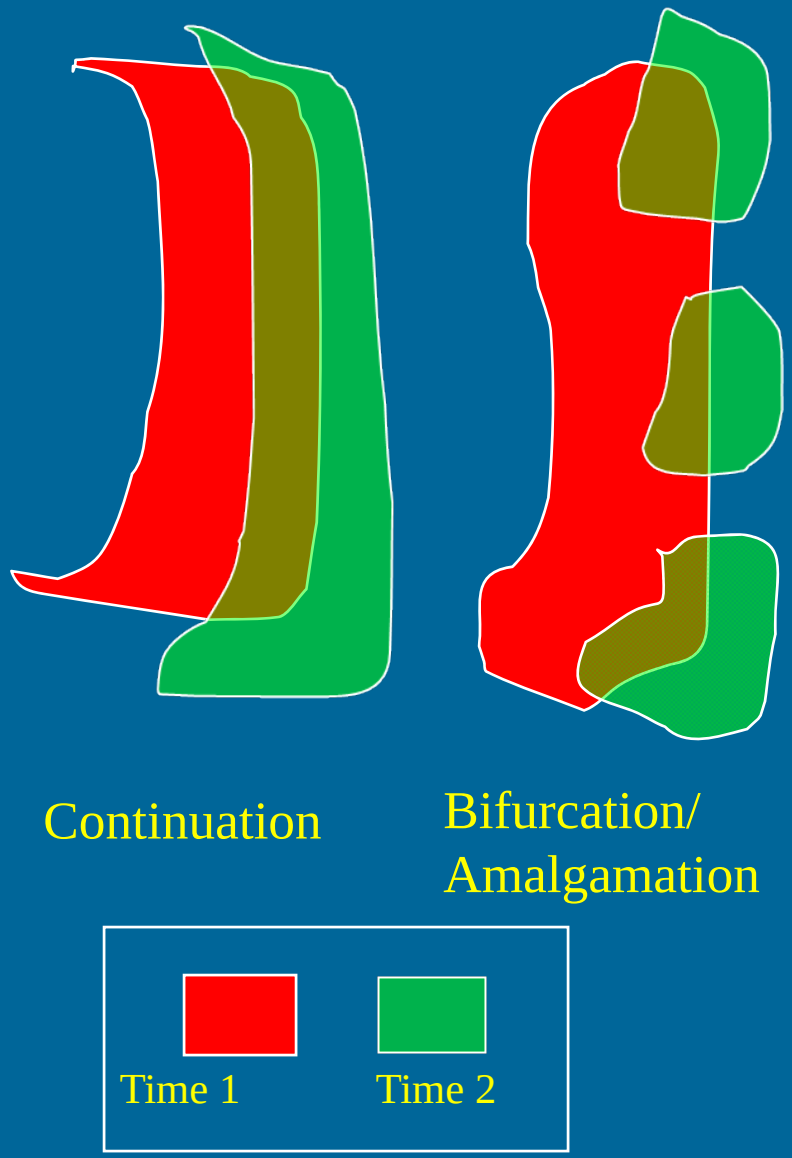
Tracking

- Continuation
- Bifurcation
- Amalgamation
- Dissipation
- Creation



Observations

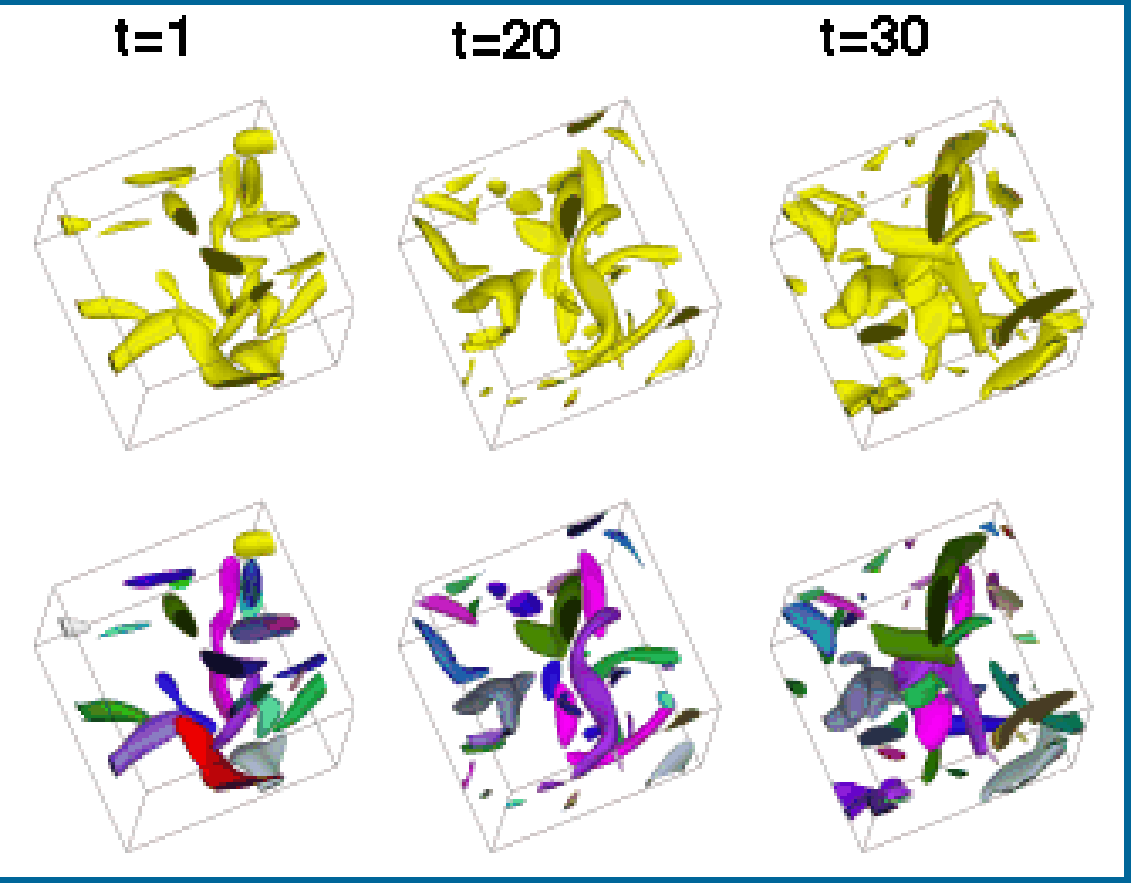
- **Continuation**: if feature O^{i}_{A} corresponds to O^{i+1}_{B}, then O^{i}_{A} overlaps with O^{i+1}_{B}.
- **Bifurcation** or **Amalgamation**: if a feature splits into a group of N objects, then all O^{i}_{A} in N overlap with O^{i+1}_{B}

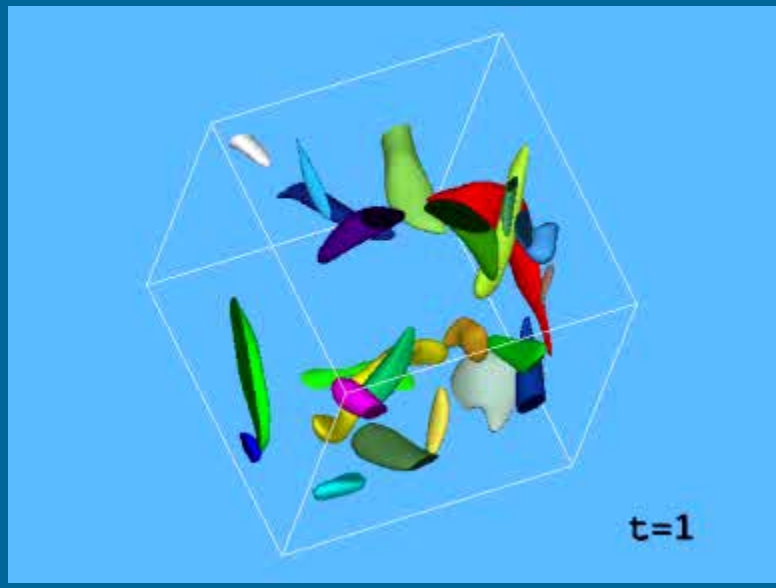


Visualization Paradigm

- DAG
- Enhanced surface rendering
- Enhanced volume rendering
- Feature isolation
- Trace and trajectory
- Feature Juxtaposition

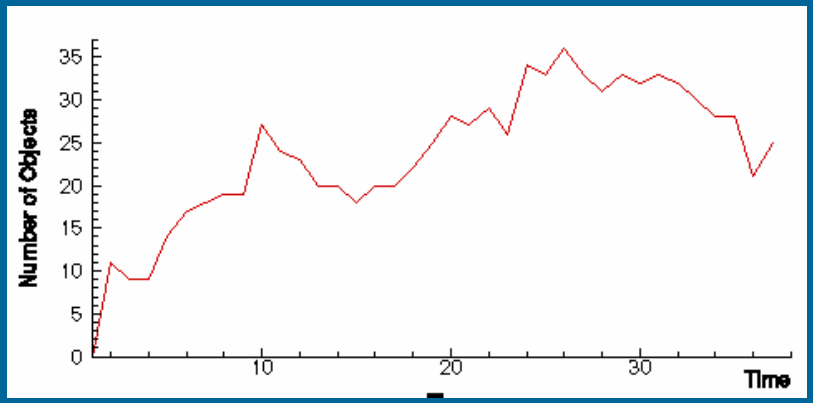
Enhanced Surface Rendering

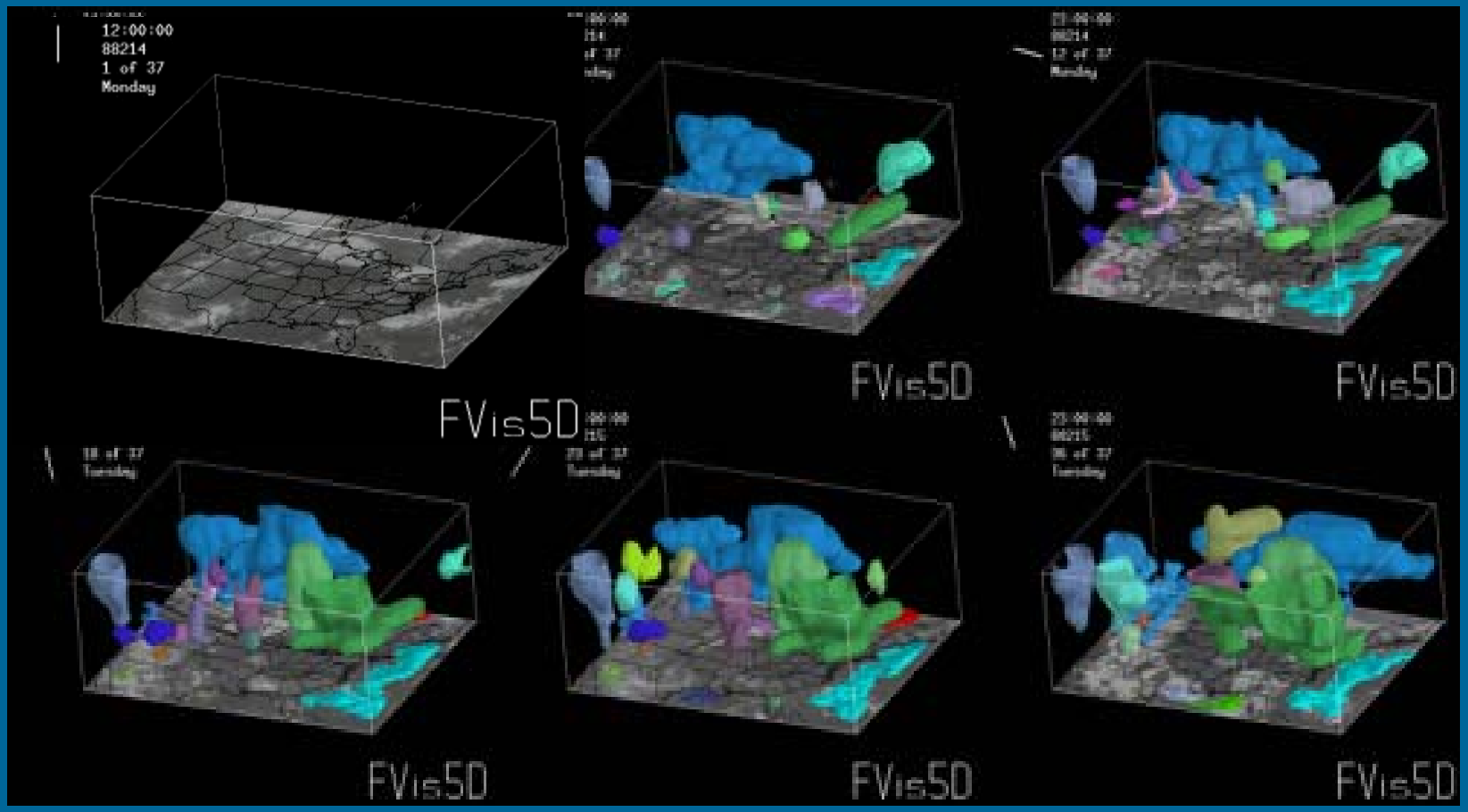




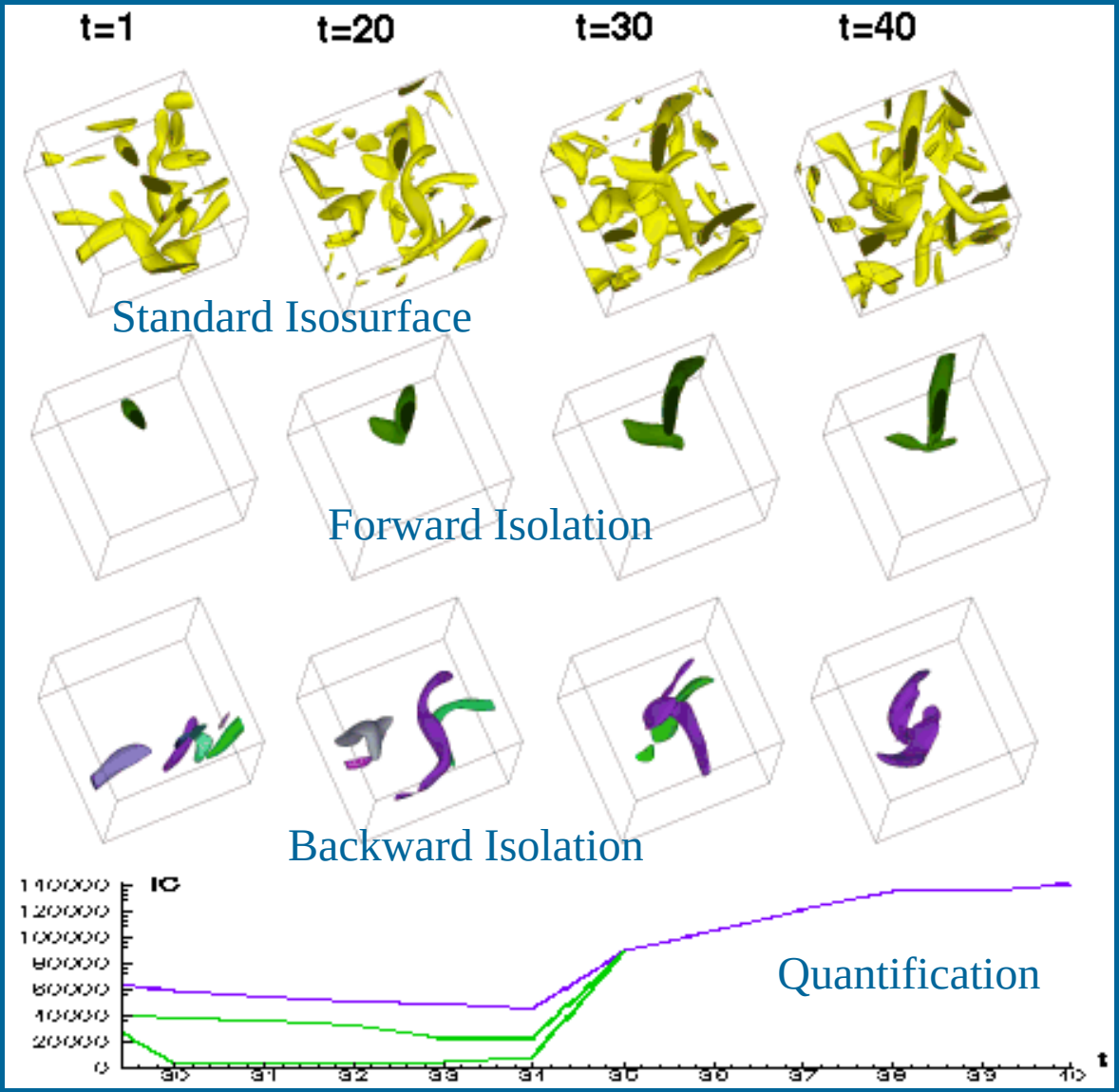
Dr. Zhang, EPA
Weather Simulation

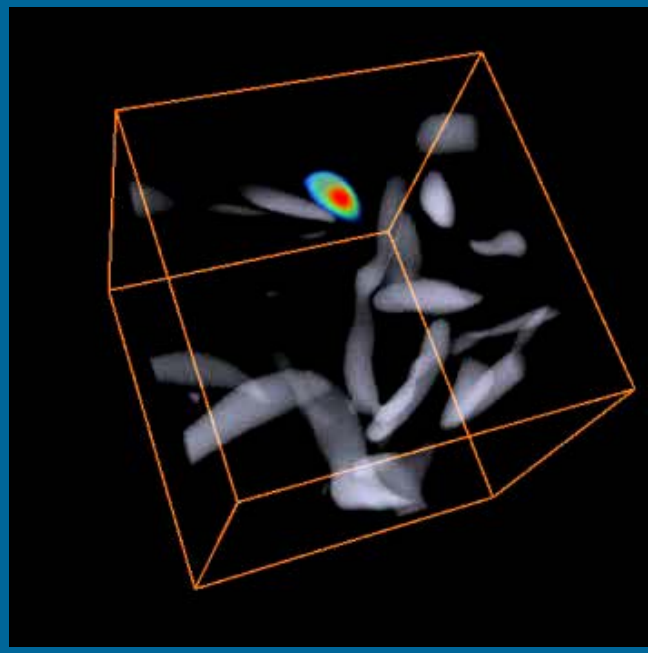
Graphs for Real-time monitoring



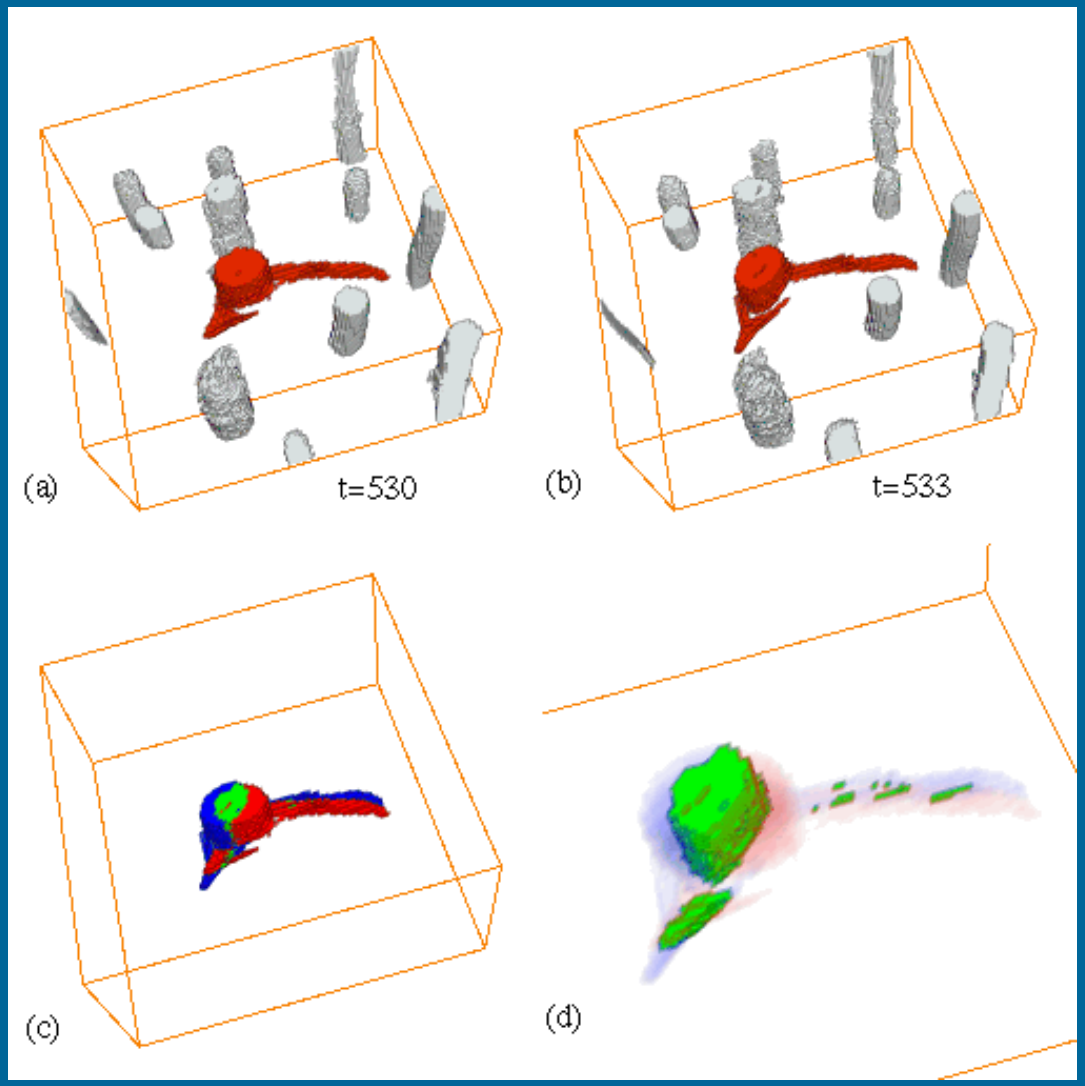


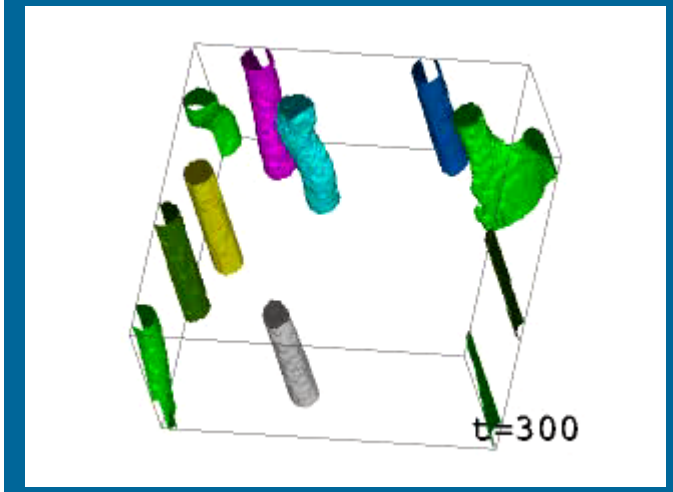
Feature Isolation/Quantification



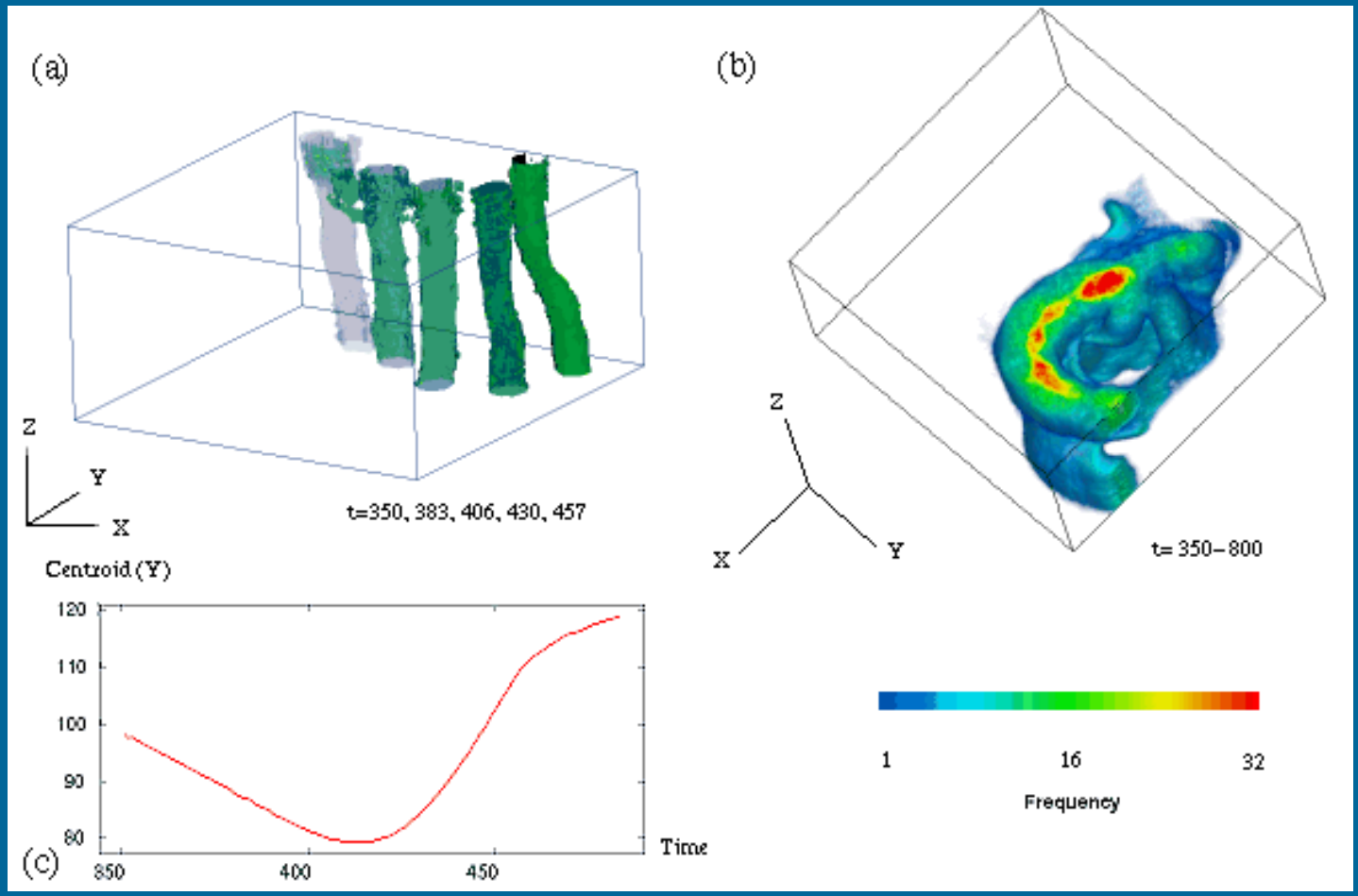


Juxtaposition

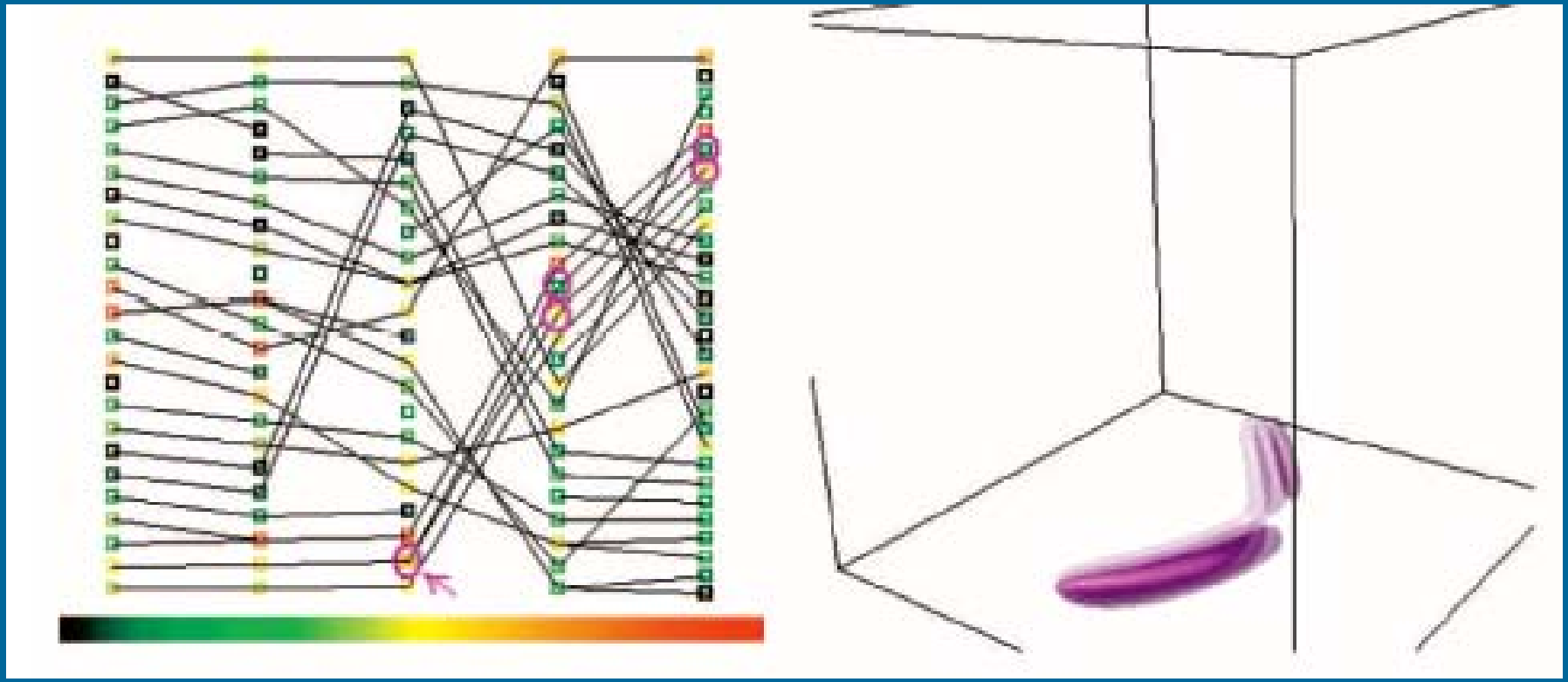




Trace and Trajectory



Event Graph Visualization

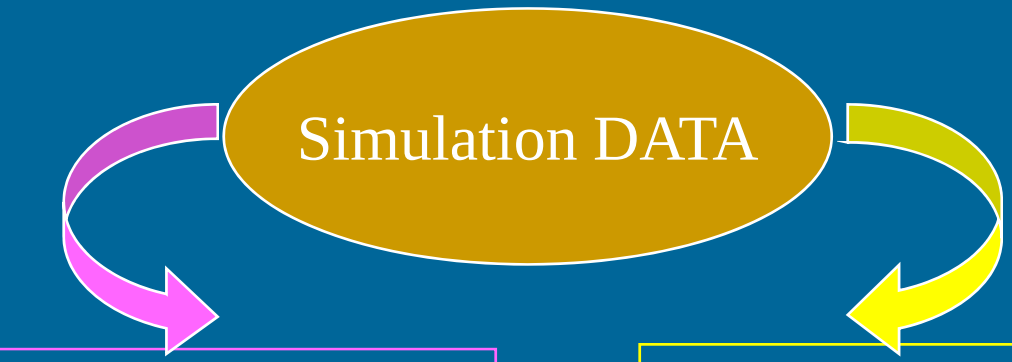


Tracking issues for Ultra-scale Visualization

- Post-processing tracking too slow, data too large → tracking while simulation is progressing
  - Feature extraction must be preset
  - Mechanism to change thresholds etc..
  - Quantities extracted
- Real time steering
- Can be used for simulation (feedback to simulation)
- Multiresolution data
- Database classification for discovery

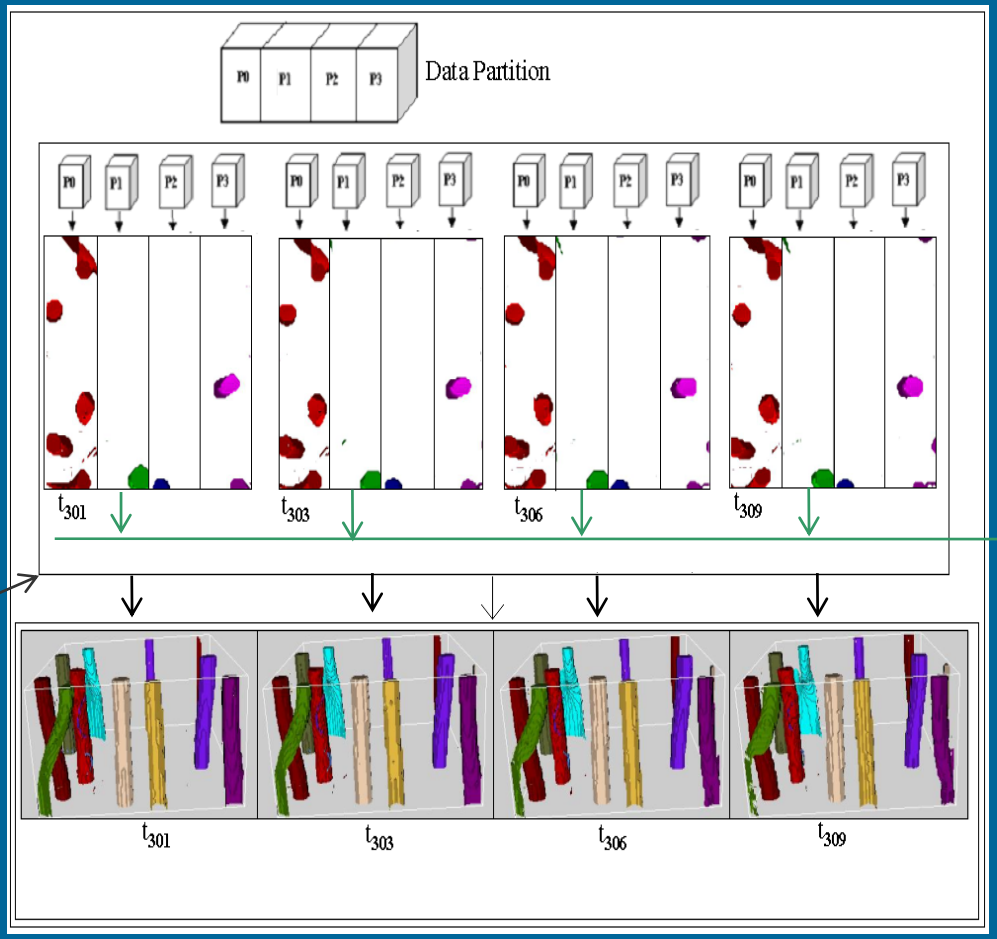
Challenges- robust code, distributed code, standard in vis packages

Tracking can be done as part of a pre- or post-processing of the data.



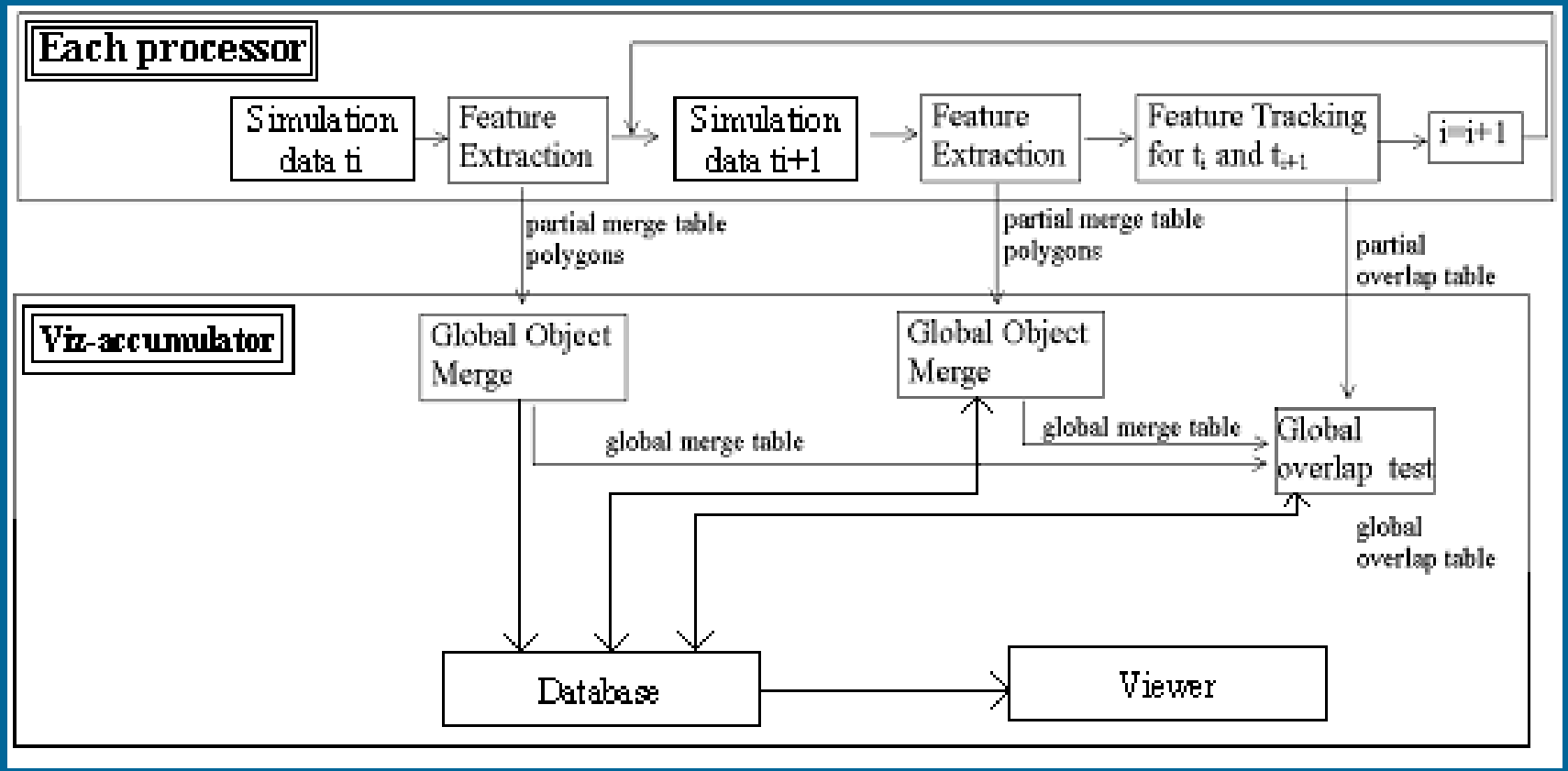
Real-time monitoring of pre-processed data

Post-Processing in-depth discovery



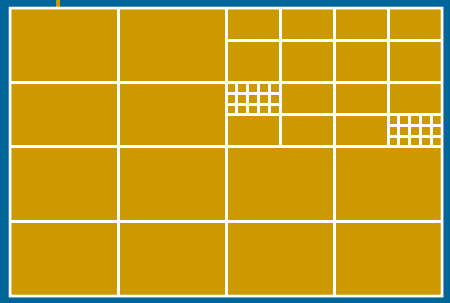
Distributed feature extraction and tracking. Each processor computes a partial extraction and tracking using ghost communications. The full solution is then merged.

Distributed Feature Tracking

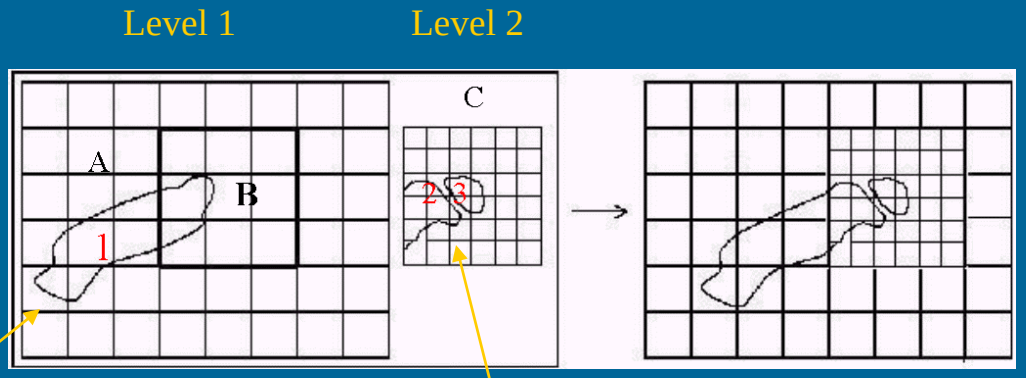


Challenges…

AMR datasets: Adaptive Mesh Refinement

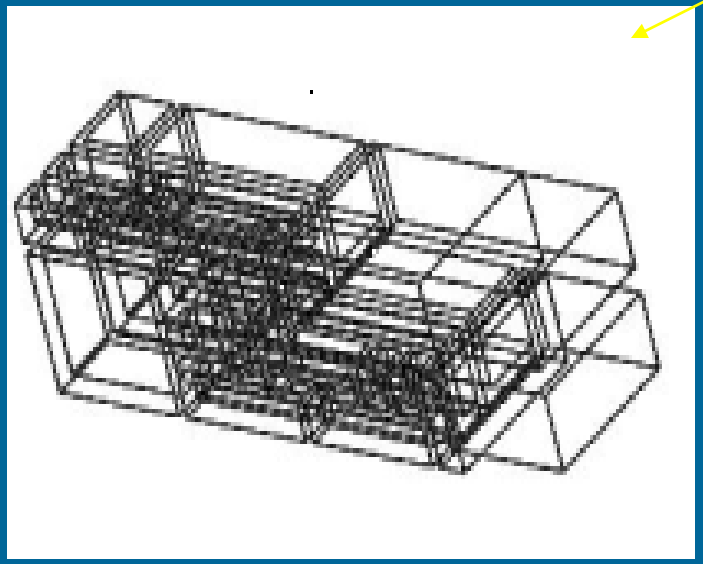


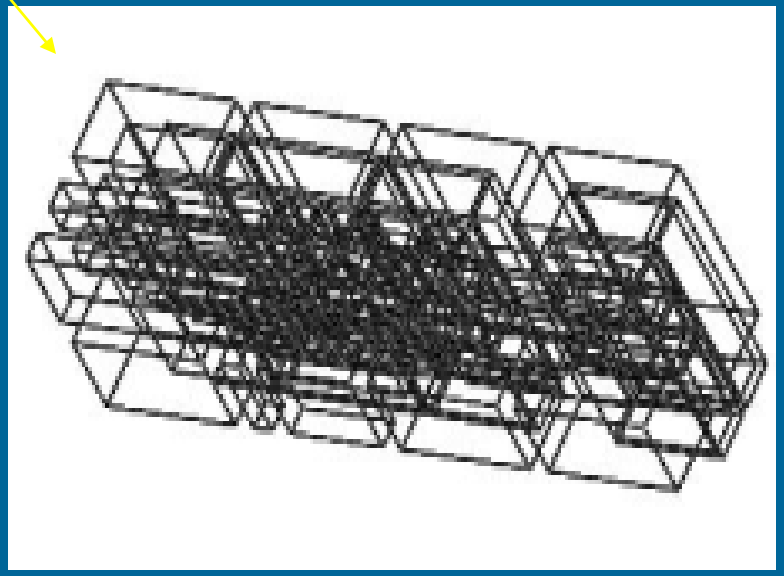
2D AMR



A splits into two pieces in Level 2: C2 and C3

Regridding from ti to ti+1



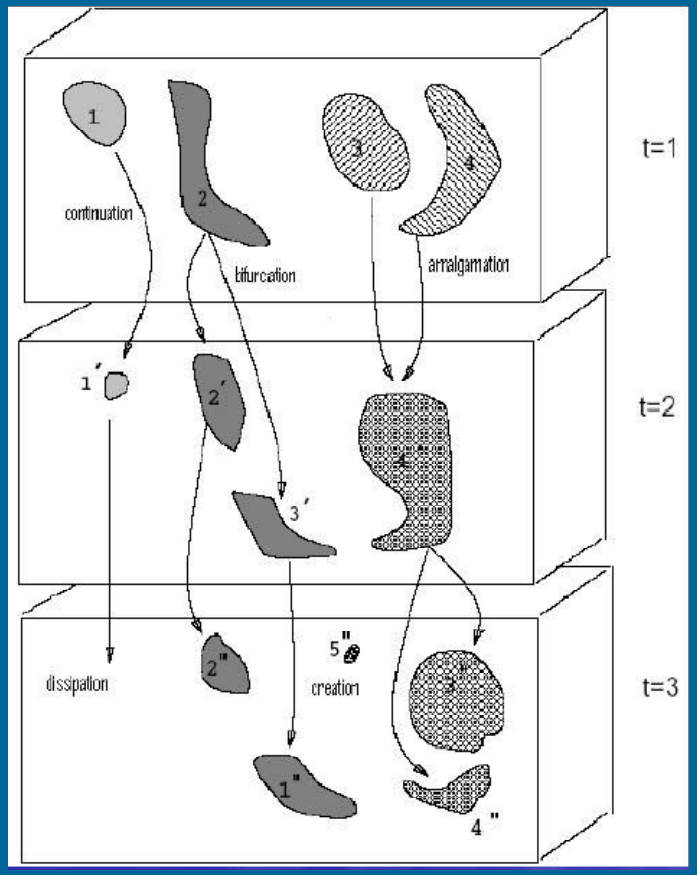


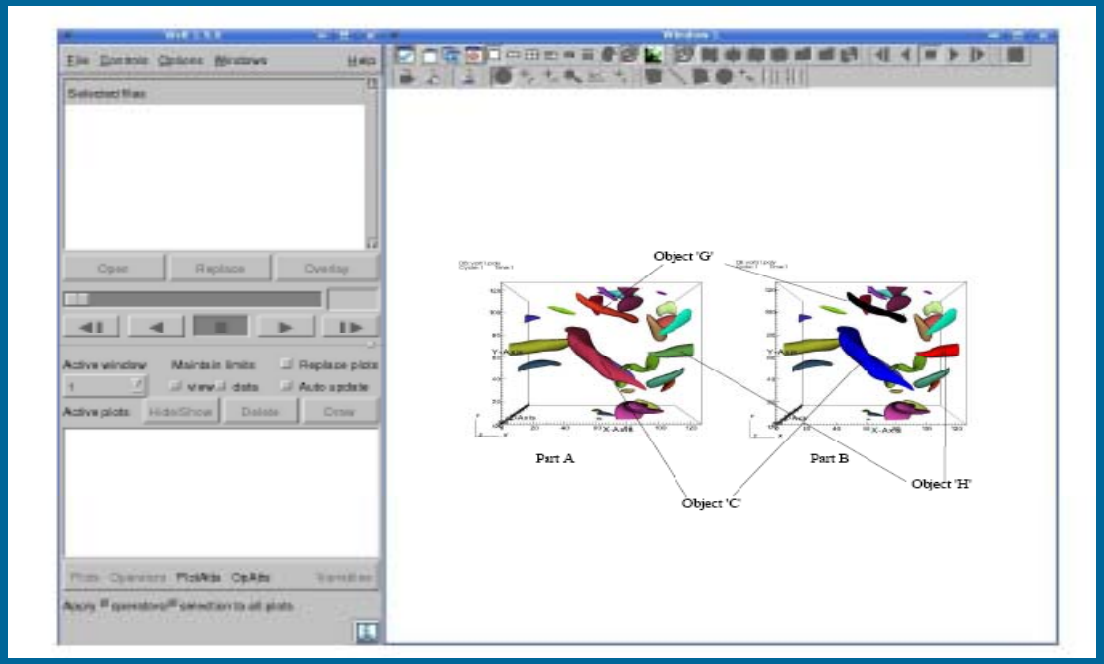
Visualization Updates

- **Feature Tracking**
- The feature extraction and tracking system, previously implemented for AVS/Express, has been ported to the VisIt visualization tool.
- In the VisIt version of the feature tracking system the computations have been decoupled from the visualization of the results, to allow faster and more flexible viewing.

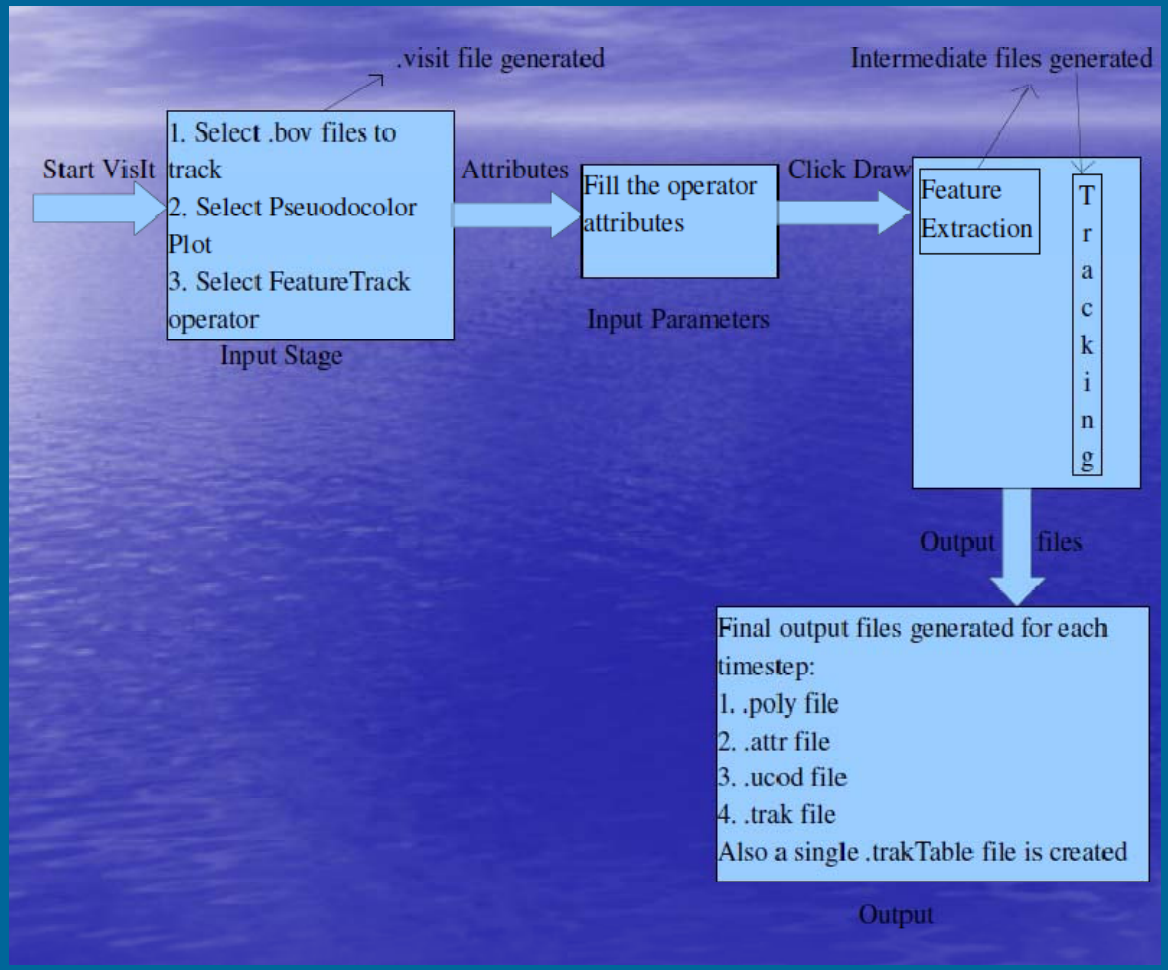
Feature Tracking within Visit

http://www.eden.rutgers.edu/~anaveen/VisIt/VisIt.html

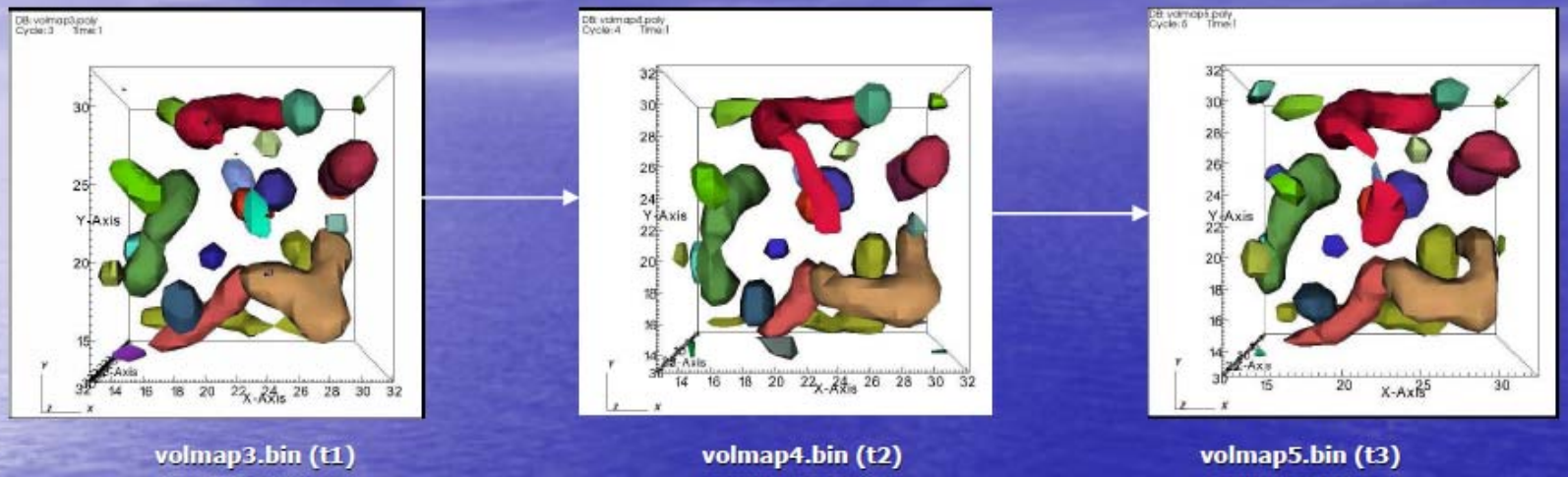




Feature Tracking pipeline



Feature Tracking and Enhanced Visualization: Change Alpha Value (Transparency) of the Displayed Objects(timesteps t1, t2 and t3)



volmap3.bin (t1) volmap4.bin (t2) volmap5.bin (t3)

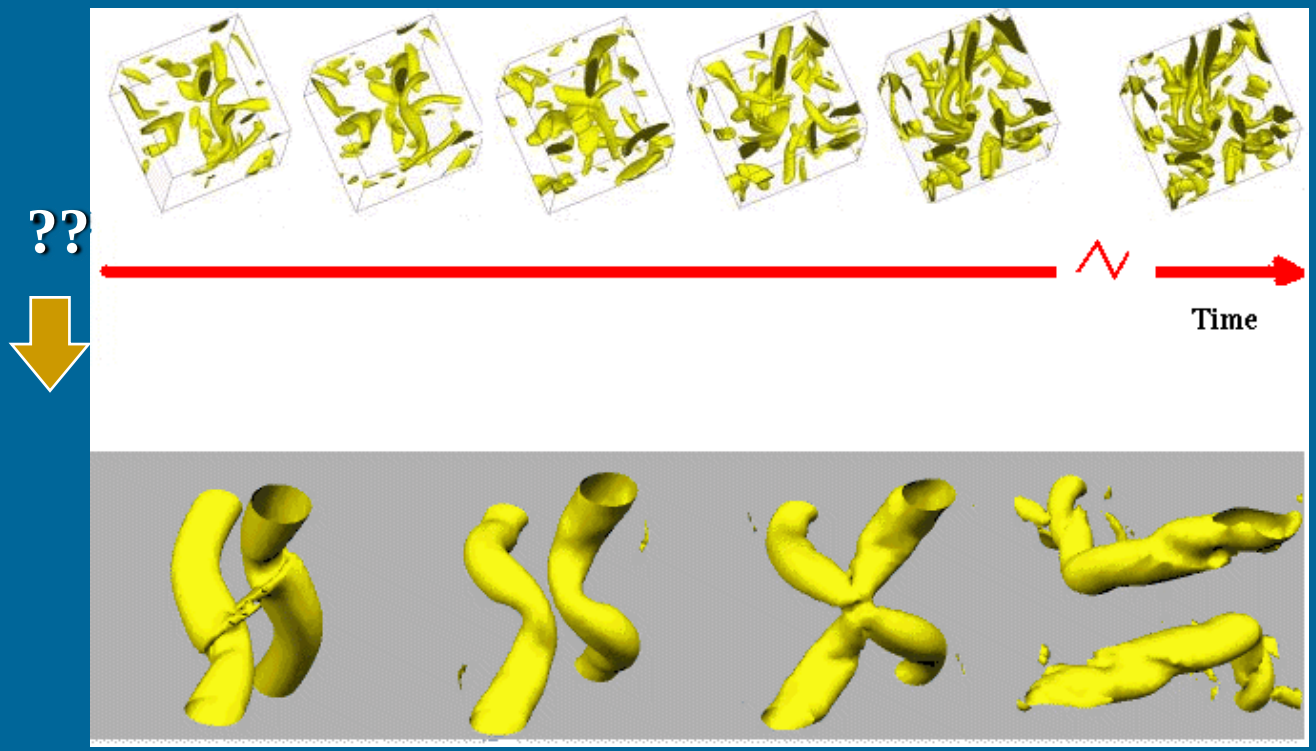
volmap3.bin (t1) volmap4.bin (t2) volmap5.bin (t3)

What next?

Event Classification

- For massive simulations
- Database querying functions (pre-processed)
- Event tracking

Example-3D Event searching



Vortex Reconnection

- Automatically find interesting events
- Follow Topological changes
- Classify events
- Search events

Data is too large to look at

- Similar to large databases – need to query the data
- “higher level queries”
- Isolate when a particular event occurs
- Show when a behavior happens or is about to happen
- Need semantics to specify the query

Feature & Event classification for Fusion-

Feature Based Techniques to characterize and catalogue interesting phenomena

Objects/Features	**Move**	**Interact ----Come Together/Apart**
(Plasma specific) Blobs Filaments Avaloids Striations Bursts Radial streamers IPO (Intermittent plasma Objects) Holes (opposite of blobs, density rarefactions) Chaotic Field line regions *(CFD-general)* bubble blast wave blobcloud critical pt. eddy hole packet patch point ring Favor roll filament separatrix finger spike gyres spiral hairpin striation helix vortex Wiggles Flux tubes Loss Cone	*(Plasma specific)* Spin/wake (blobs) Zonal flows Flow shears Rotation *(CFD general)* advect swirl entangle transport disperse wind flow hop migrate stream	*(Plasma specific)* Coalesce (blobs) Breakup (blobs) *(CFD General)* accrete aggregate align bind bifurcate burst collapse condense disassemble disrupt finger fission focus fold fuse pair roll-up plow reflect scatter spike split striate strip wind about

Characterization of events for combustion

Objects				Move		Interact ----Come Together/Apart		
Combustion specific				*Combustion specific*		*Combustion specific*		
Kernal Flame (premixed, part, diffusion,edge) Shockwave Fuel Jet Stochiometric Line Region of chemical reaction Region of Flow				burn curve convect diffuse ignite	quench percolate propagate reignite react strain	flame-wall interactions merge annihilate upstream annihilate downstream		
CFD-general				*CFD-general*		*CFD General*		
bubble blast wave blobcloud critical pt. eddy	hole packet patch pint ring	favor filament finger gyre hairpin helix	roll separatrix spike spiral striation vortex	advect entangle disperse flow hop migrate	stream swirlt transport wind	accrete aggregate align bind bifurcate breakup burst collapse	condense disassemble disrupt finger fission focus fold fuse pair	roll-up plow reflect scatter spike split striate strip wind about

Challenges

- MOST IMPORTANT: Usable extraction/tracking code – either libraries or end applications to allow scientists to try it and not just visualization experts

Challenges

- Track neighborhoods, not just atomic features
- Characterize events – sequences of actions not just the “simple” tracking actions
- Data structure to store events (multimedia data structures)
- Each domain has its own events – are there commonalities so that a generic system could be developed?

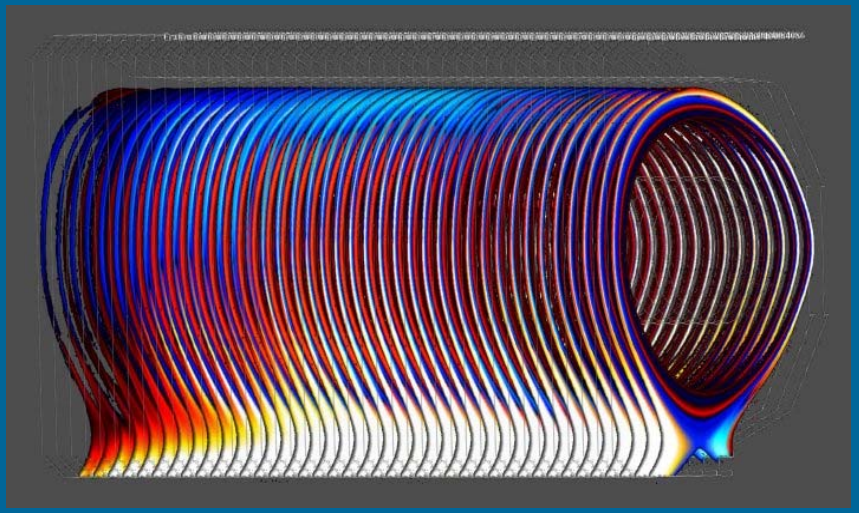
Challenges

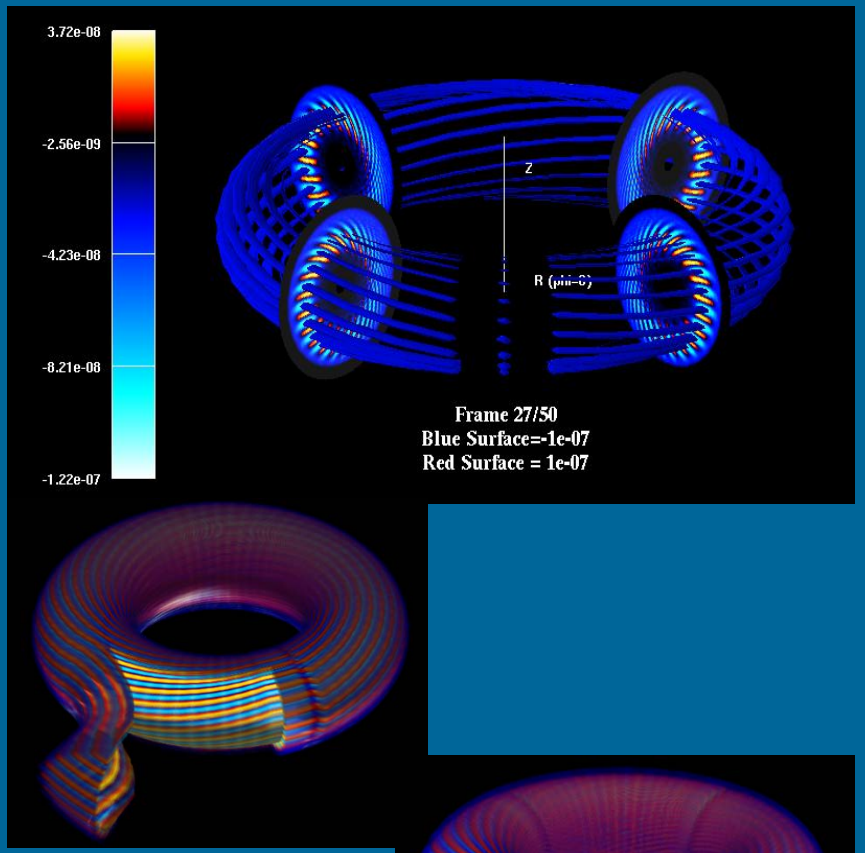
- New meta-data is created which also creates new visualization issues
- Feature data base
- Event comparisons, event monitoring, control
- What is the best way to present tracking information (perceptual issues).

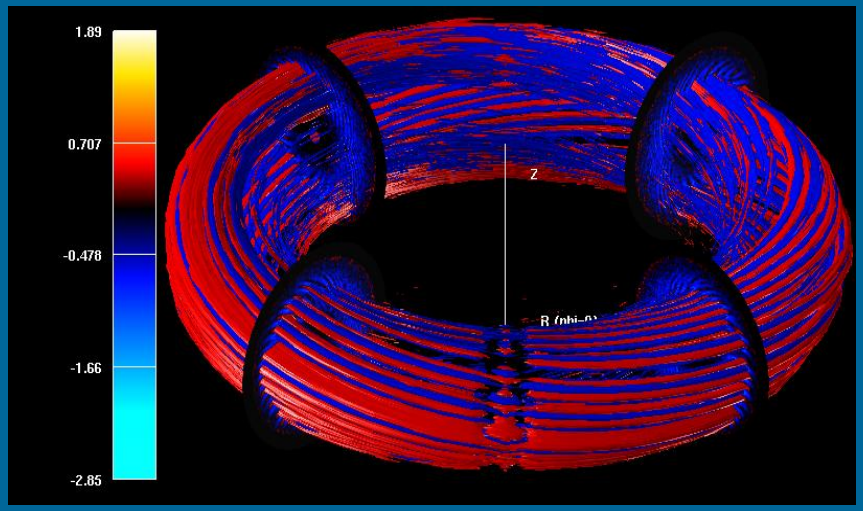
Why Feature Tracking

- Reduce the Size of Data
- Reduce Complexity
- Provide Quantification
- Enhance Visualization
- Feature based QUERYING
- Facilitate Event Searching
- Help with code comparisons, help with simulation/observation analysis. Can only be done on a higher level comparion

CPES Visualization







Thank You!!

http://www.caip.rutgers.edu/vizlab.html