Large Scale Time-Varying Data Visualization

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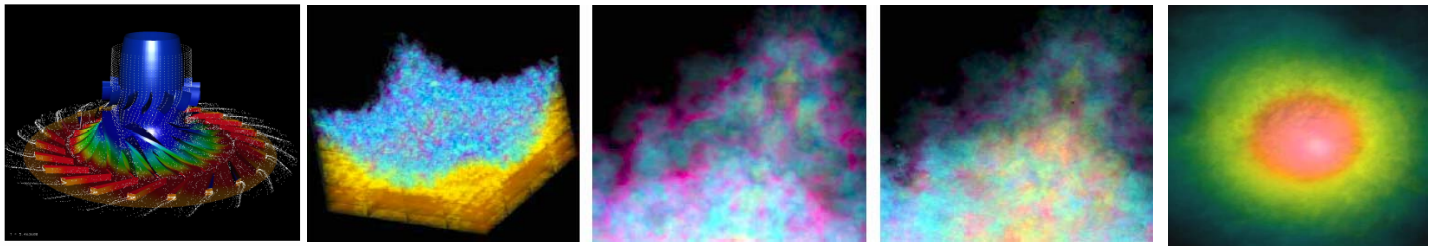
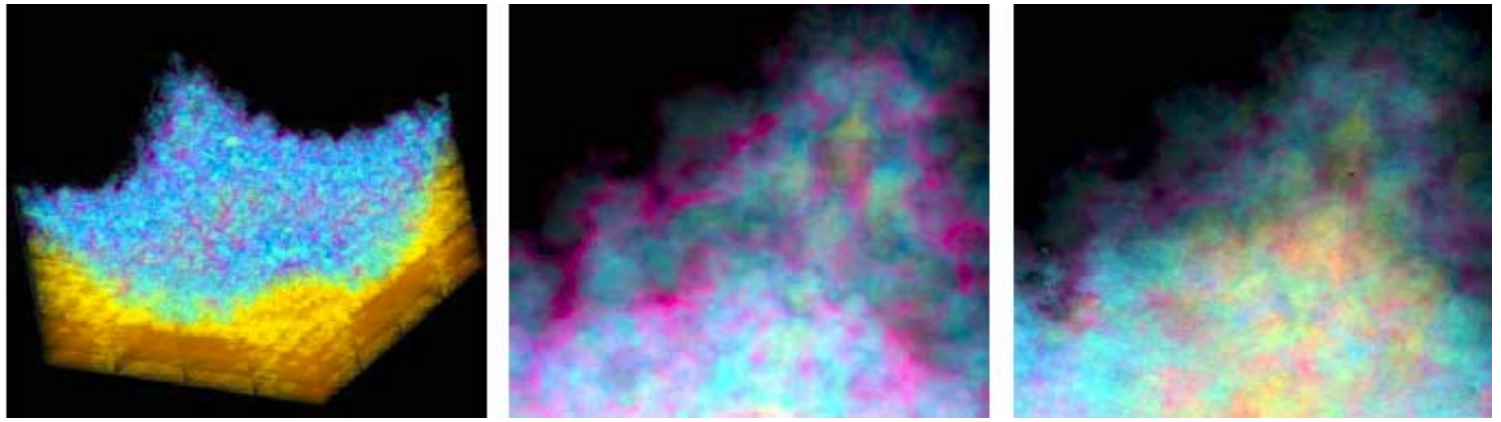


Applications

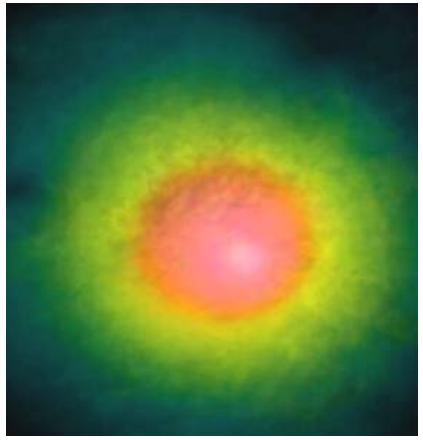
- Large Scale Time-Dependent Simulations
- Richtmyer-Meshkov Turbulent Simulation (LLNL)
  - 2048x2048x1920 grid per time step (7.7 GB)
  - Run 27,000 time steps
  - Multi-terabytes output

LLNL IBM ASCI system

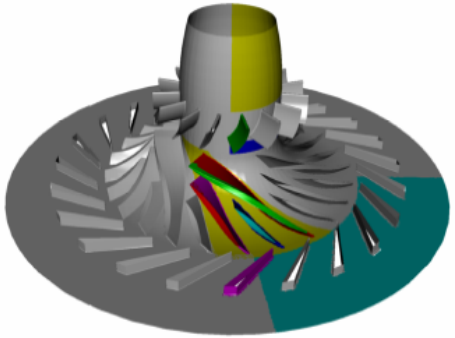


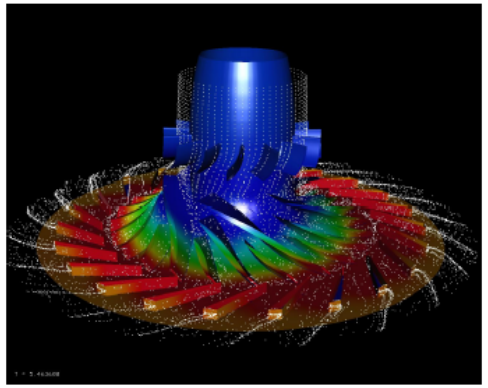
Applications

- Oak Ridge Terascale Supernova Initiative (TSI)
  - 640x640x640 floats
  - > 1000 time steps
  - Total size > 1 TB
- NASA's turbo pump simulation
  - Multi-zones
  - Moving meshes
  - 300+ time steps
  - Total size > 100GB



ORNL TSI data

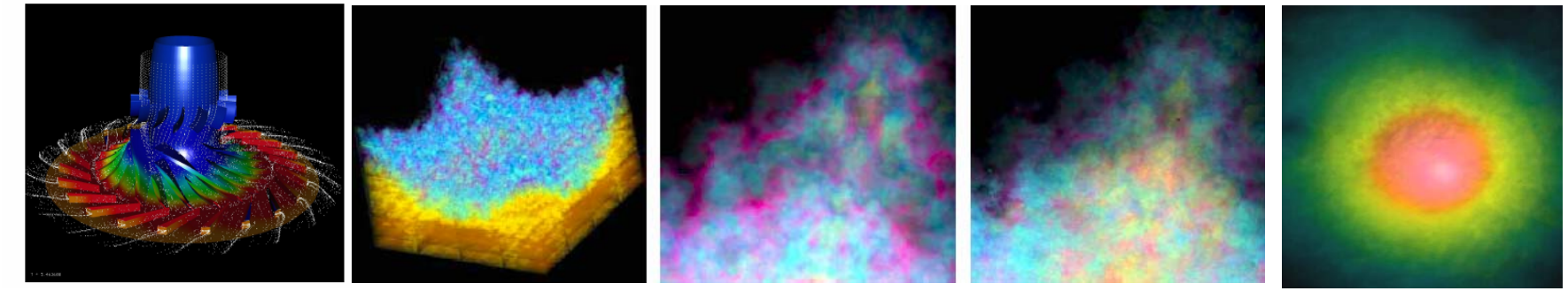




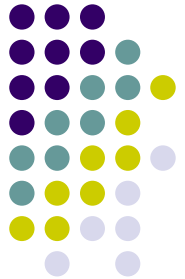
NASA turbo pump

Research Goals and Challenges

- Interactive data exploration
  - Quick overview, detail on demand
- Feature enhancement and tracking
  - Display the “invisible”
  - Understand the evolution of salient features over time
- Challenges
  - managing, indexing, and processing of data



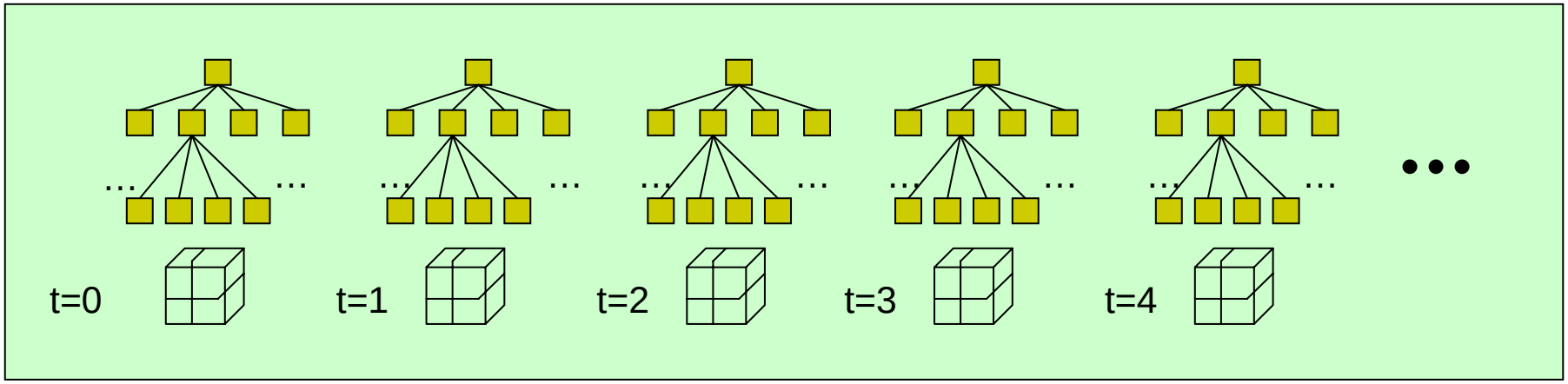
Research Focuses



- Multi-resolution data management schemes
- Acceleration Techniques
  - Efficient data indexing
  - Coherence exploitation
  - Effective data culling
  - Parallel and distributed processing
- Feature tracking and enhancement
  - Visual representation
  - Geometric tracking

Multiresolution Data Hierarchy

- Goal: allow interactive spatial-temporal data browsing at arbitrary scales
- Based on wavelet transform and Huffman encoding
- Create a multiresolution data hierarchy called wavelet based time-space partitioning tree (WTSP tree)



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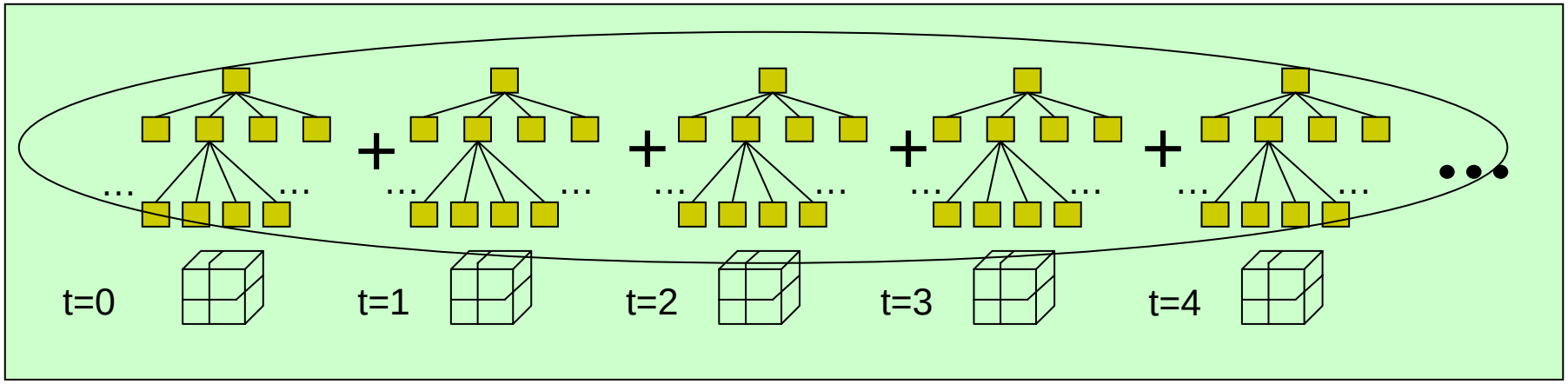
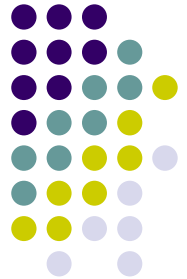


Multiresolution Data Hierarchy



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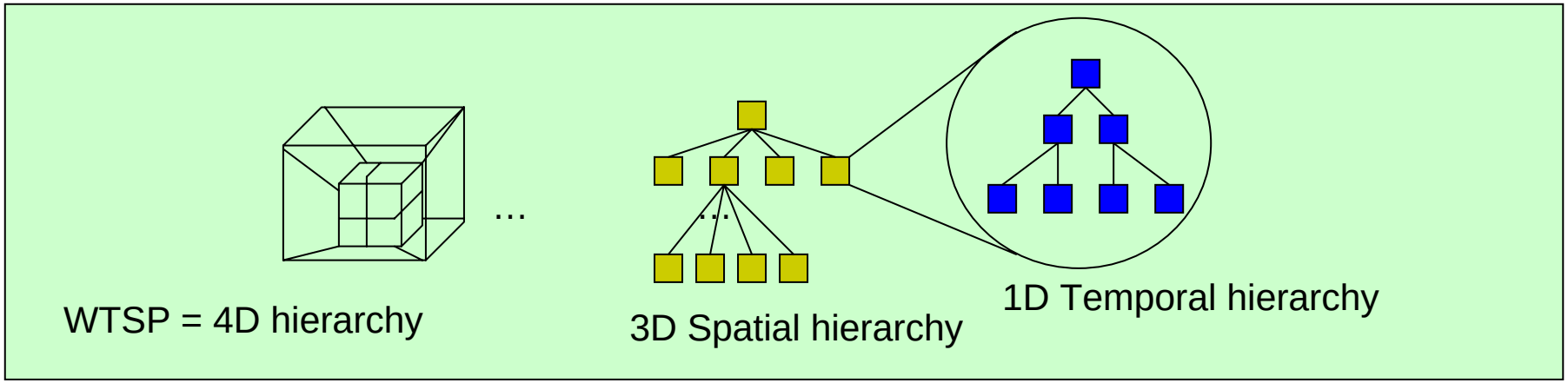
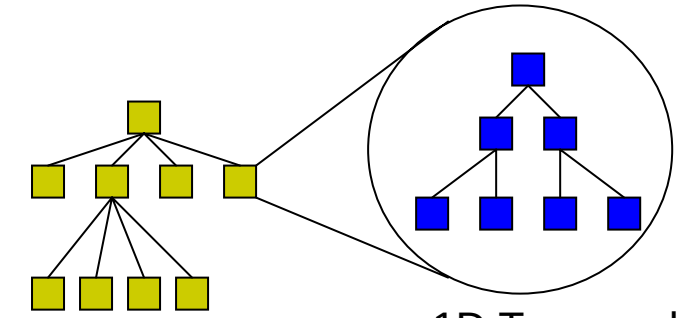


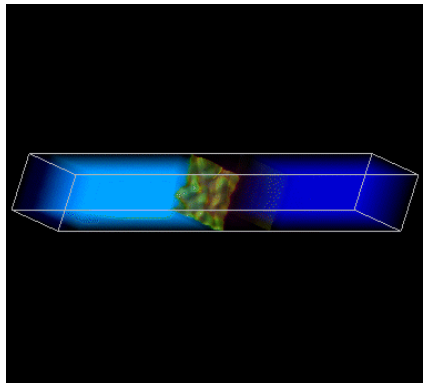
Accelerated Techniques

- Utilize temporal coherence
  - Coherence in image
  - Coherence in visibility
  - Coherence in indices

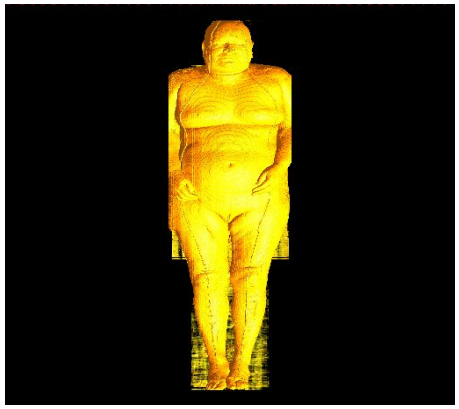


3D Spatial hierarchy

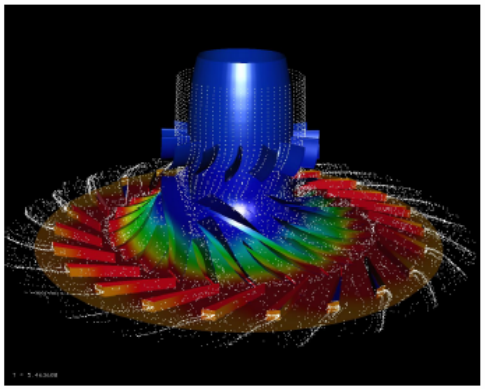
1D Temporal hierarchy



11.2 speedup, 3.4% image diff.

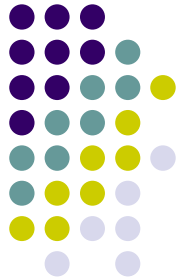


75% invisible blocks removed

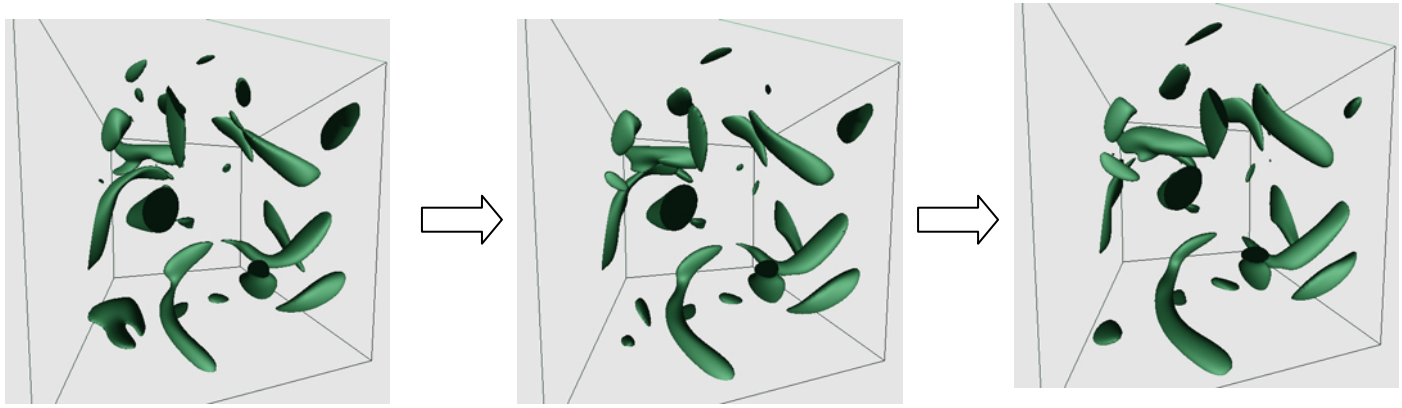


80% space saving for indices

Feature Tracking and Enhancement



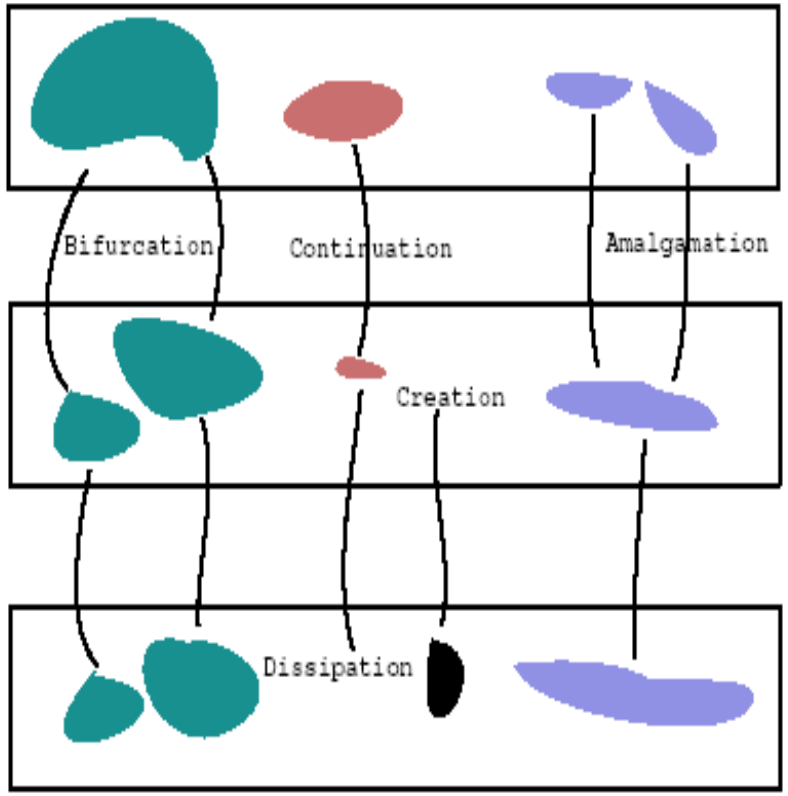
- Two main goals:
  - Identify correspondence



  - Detect important evolution events and critical time steps

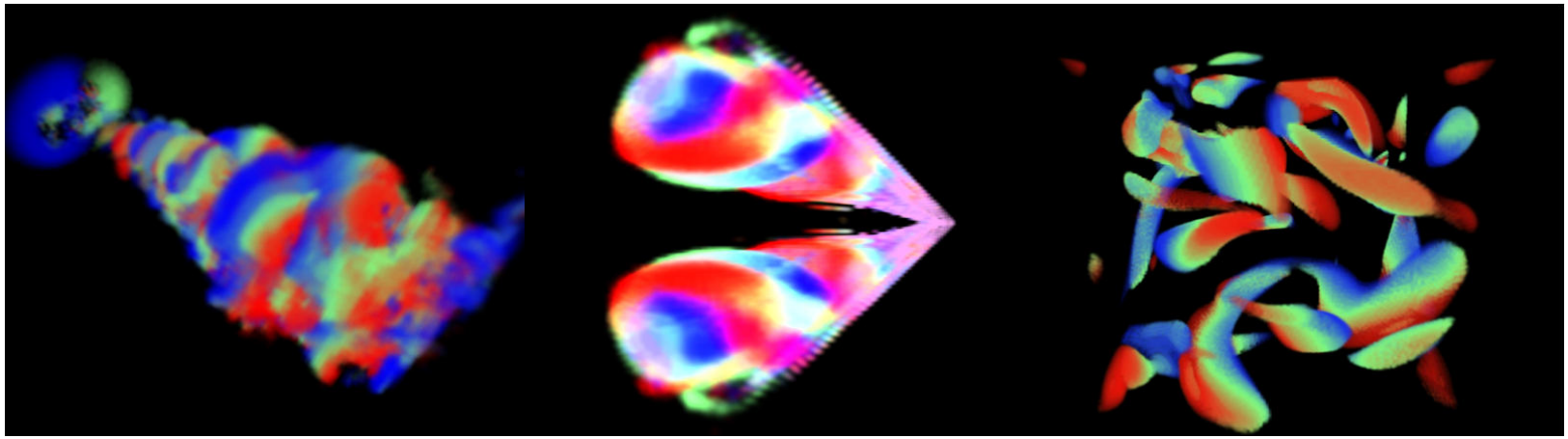
Strategy 1: Computing 4D Geometry

- 3D time-varying = 4D
- Extract “isosurfaces” from 4D hypercubes
- Slice the 4D geometry to get the surface at the desired time step
- Analyze the 4D geometry to discovery important evolution events



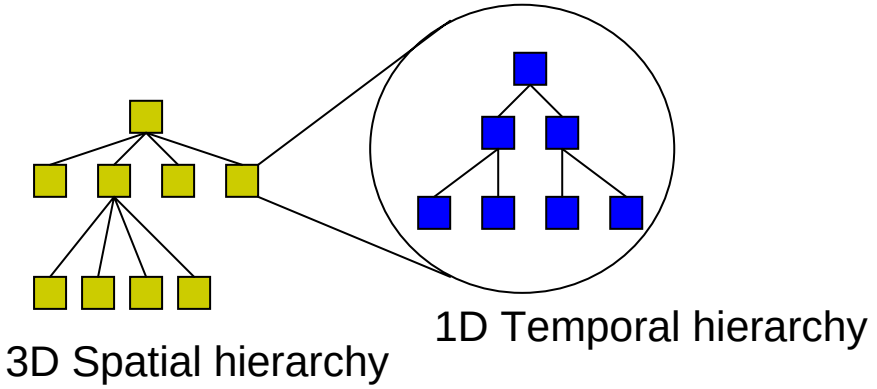
Strategy 2: High Dimensional Visualization

- Hyper-Projection to 3D image plane and then use graphics hardware to perform real time rendering



Parallel Computation

- To utilize the parallel computation power, we need to partitioning and distribute the hierarchy
- Effective data management is a must!
  - Eliminate data dependency while minimizing data replication
  - Ensure run time load balancing
  - Efficient streaming and caching of raw or reconstructed data from the data repository



Summary

- We are now able to efficiently visualize large scale time-varying data generated by DOE scientists
- Most of the algorithms are run on either local workstations or clusters
  - One of the major challenges remained is actually how to move data
- Inter-operability among different algoirthms and software components will be a key for practical uses