Topological Analysis for the Exascale Computing Project (ECP)
ECP ALPINE: Algorithms and Infrastructure for In Situ Visualization and Analysis

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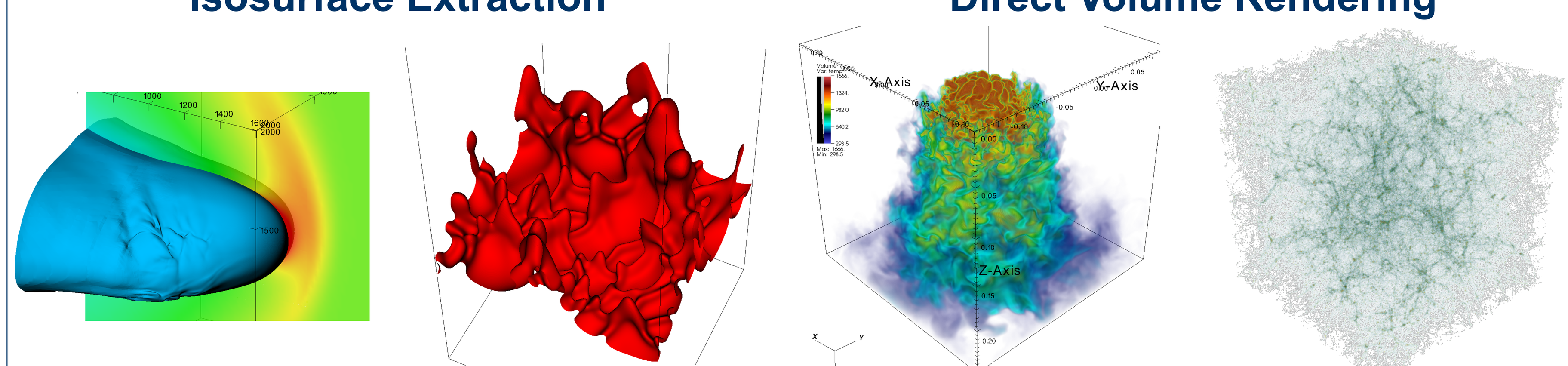
ECP ALPINE: Algorithms and Infrastructure for In Situ Visualization and Analysis

ALPINE is a cross-institution (LANL, LBNL, LLNL, U. of Oregon, Kitware) effort to leverage successful Data Analysis and Visualization software to deliver **in situ infrastructure and algorithms directly to ECP Applications**. The project focuses on four development areas:

- Deliver exascale **visualization and analysis algorithms** that will be critical for ECP Applications as the dominant analysis paradigm shifts from *post hoc* (post-processing) to *in situ* (processing data in a code as it is generated).
- Deliver an exascale-capable **infrastructure** for the development of in situ algorithms and deployment into existing applications, libraries, and tools.
- Engage with ECP Applications to **integrate** our algorithms and infrastructure into their software.
- Engage with ECP Software Technologies to **integrate** their exascale software into our infrastructure.

In Situ Visualization Requires Automatic Parameter Selection

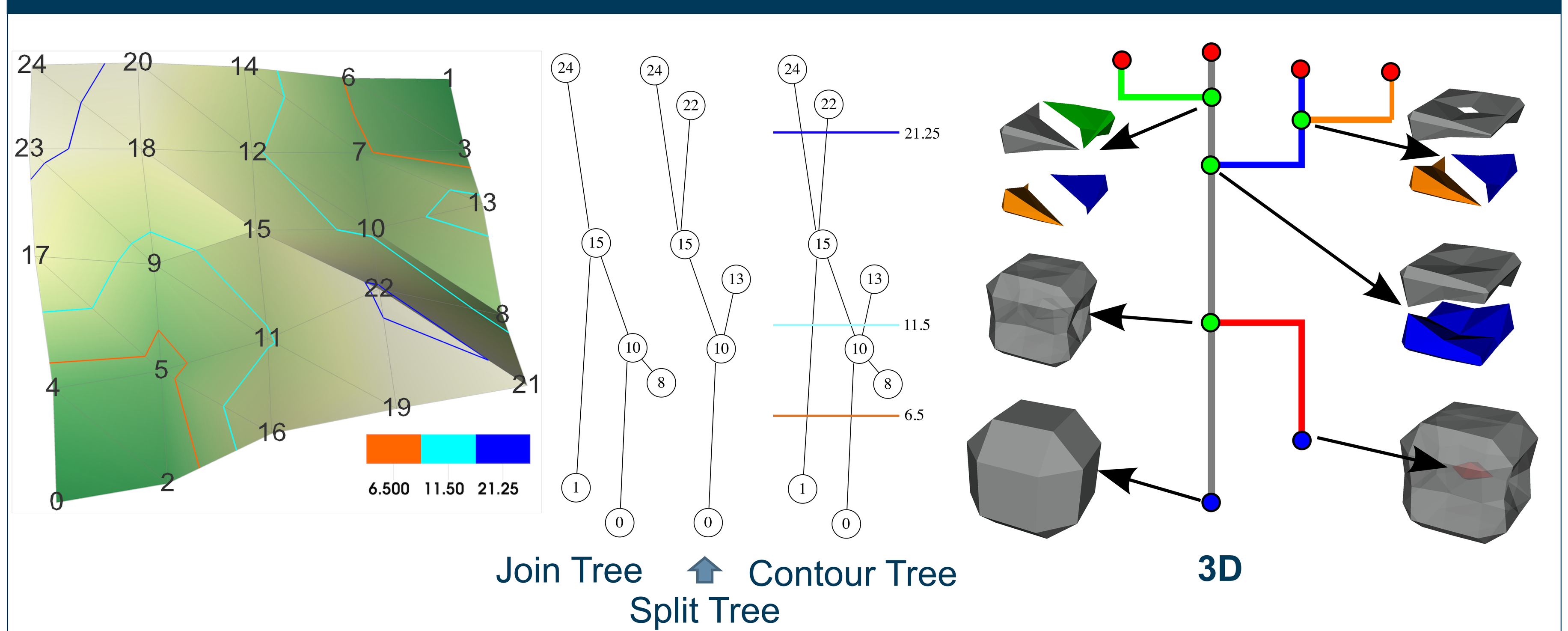
Isosurface Extraction | **Direct Volume Rendering**



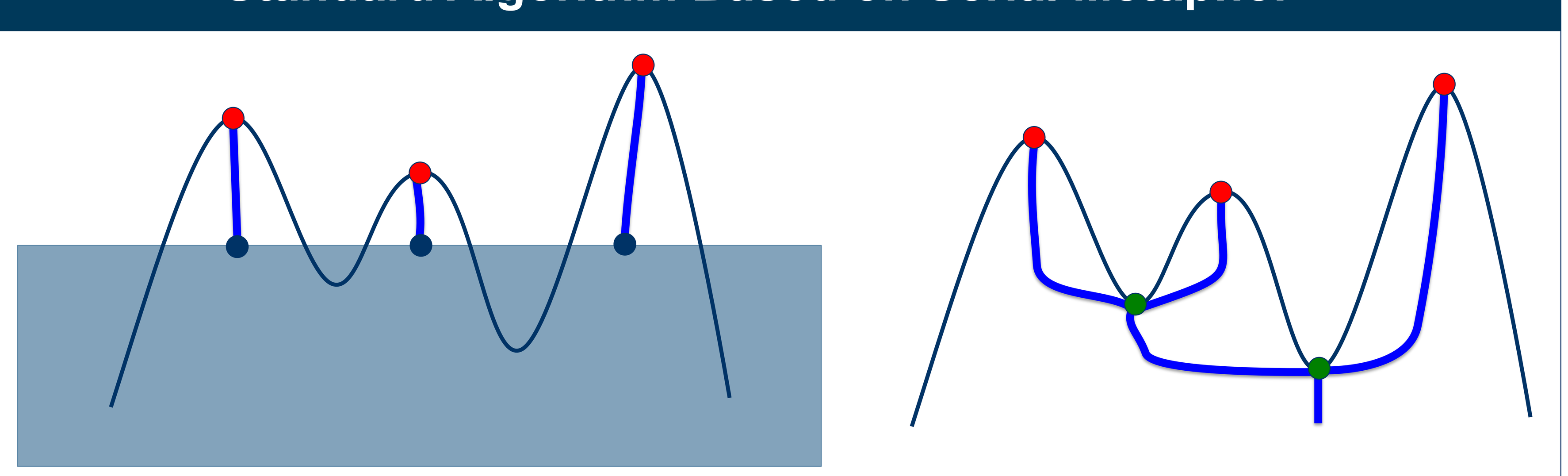
Shape of heliopause (Data: Sergey Borovikov, UA Huntsville) | Isotherm in hydrogen flame (data : LBNL CCSE) | Temperature in hydrogen flame (data courtesy of LBNL CCSE) | Density distribution in universe (data courtesy of LBNL CCSE/C³)

- **Isosurface extraction** and **direct volume rendering** most common methods for visualizing scalar data
- Both rely on parameters chosen by user:
  - Isosurface extraction: Isovalue(s)
  - Direct volume rendering: Transfer function
- When running visualization *in situ*, need to choose these parameters automatically
- Automatic choice does not need to be perfect (save multiple images in Cinema DB), but should provide reasonable down-selection

The Contour Tree Summarizes Isosurface Behavior

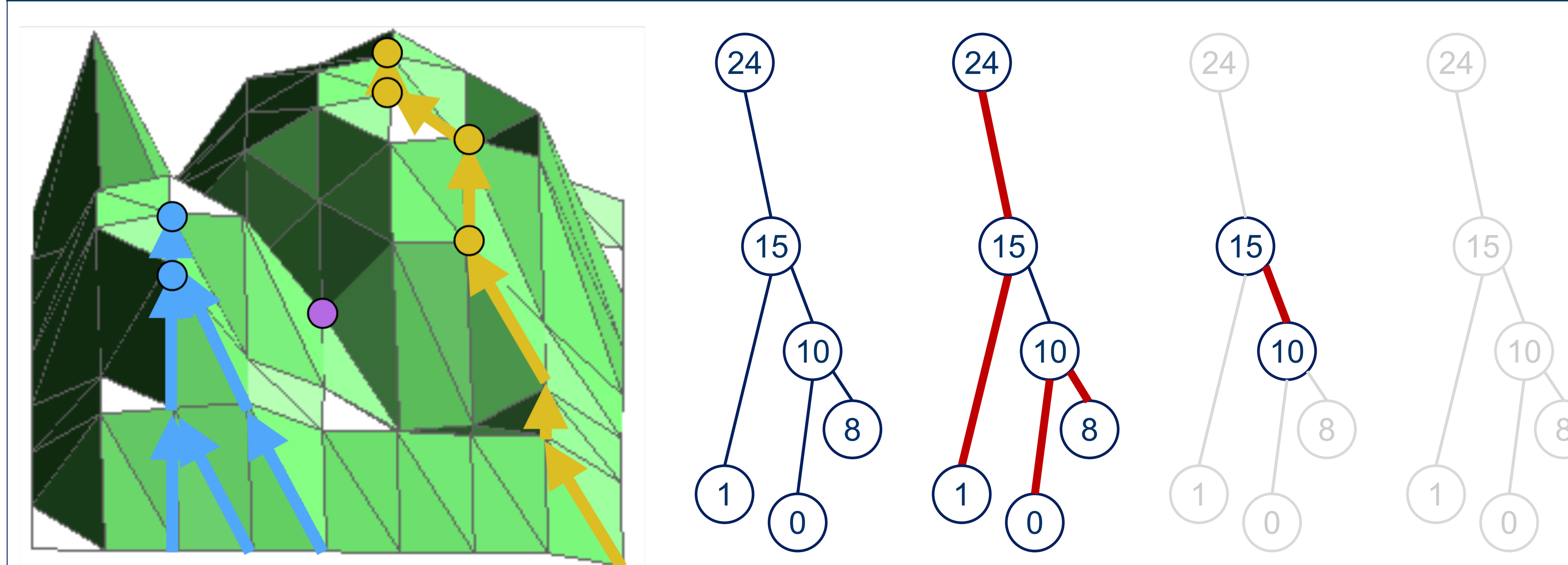


Standard Algorithm Based on Serial Metaphor



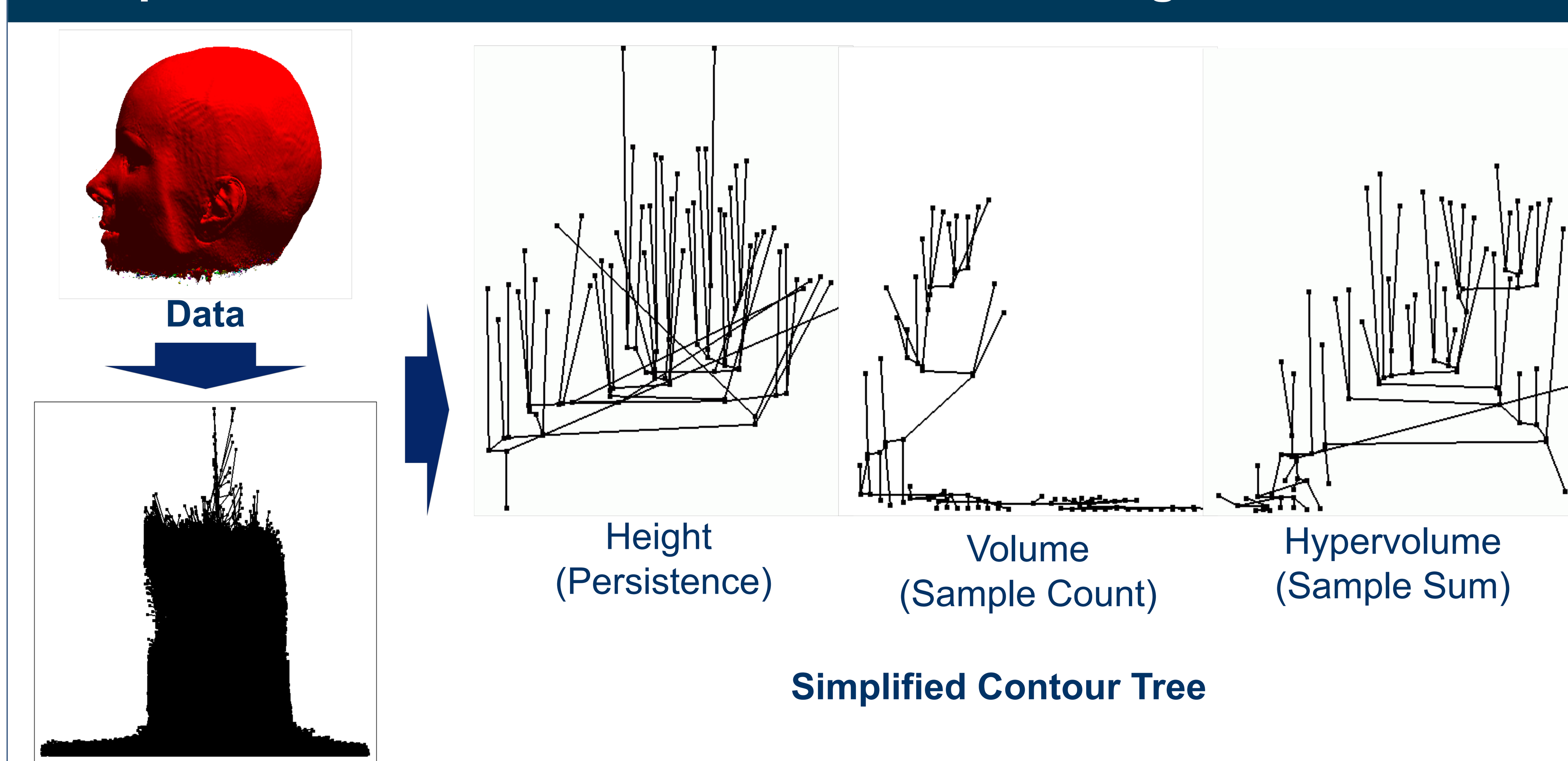
- "Drain" terrain submerged in water and record components that appear above surface

Efficient Parallelization by New Approach: Parallel Peak Pruning



Find paths to peaks & pits | Successively prune leaves

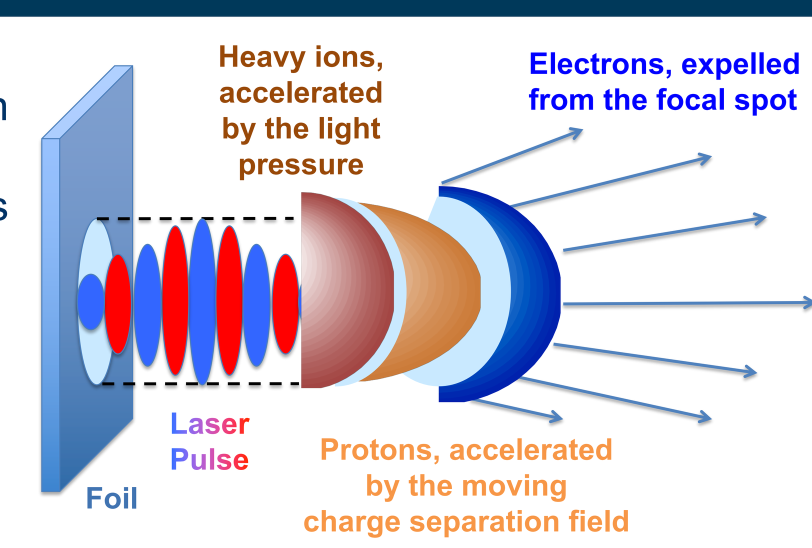
Simplification Reduces Contour Tree to Most Significant Features

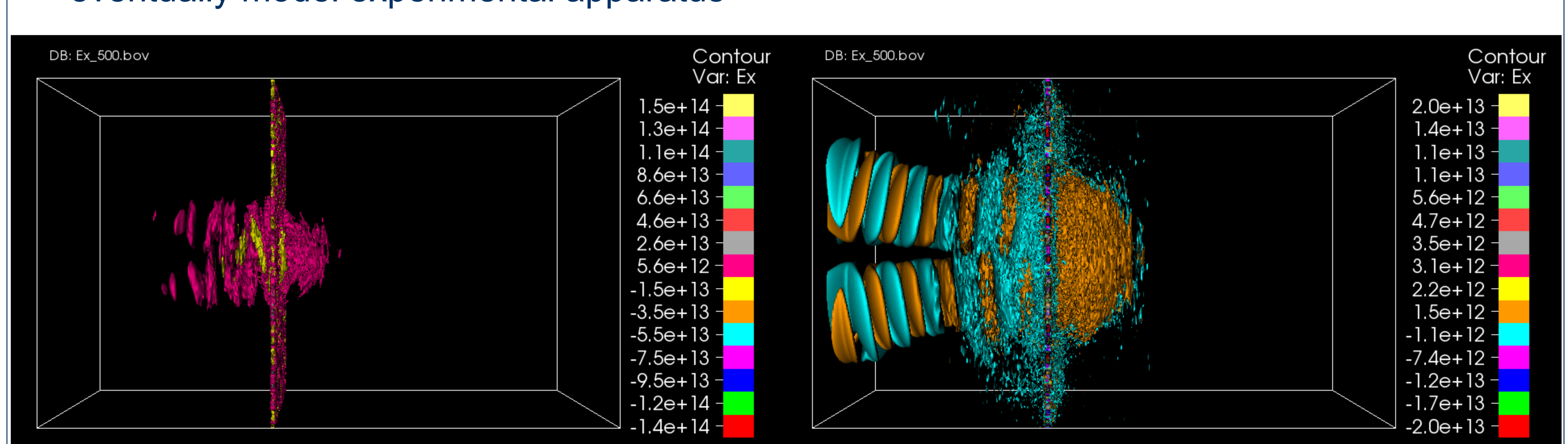


Simplified Contour Tree

Example Application: Ion Accelerator Simulation (Warp)

- Interaction of intense laser with plasma sheath offers the possibility of compact and cheaper ion sources for many applications, including:
  - Fast ignition and radiography of dense targets
  - Injection into conventional accelerators
  - Hadron therapy
- Potential advantages for cancer therapy:
  - Precise control over depth at which energy is deposited results in less tissue damage
  - Relatively compact and cheap
- This is an active area of research, simulations are used to develop and prove theory and will eventually model experimental apparatus





Equally spaced isovalues | Isovalues obtained by topological analysis

Acknowledgments

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