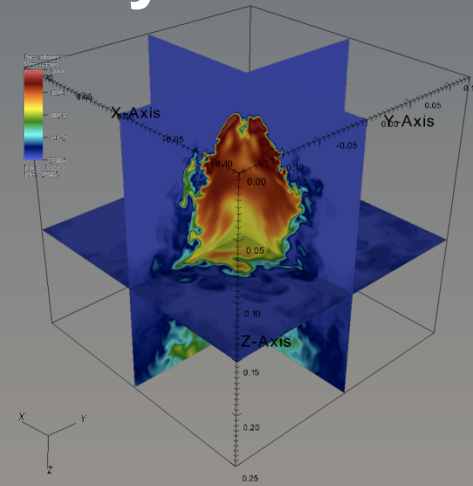
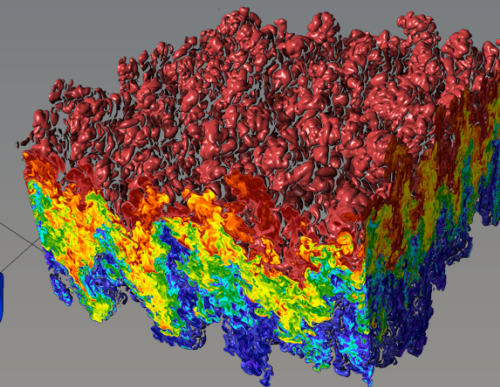
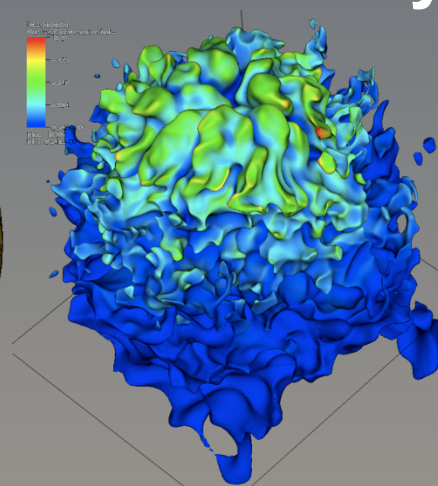
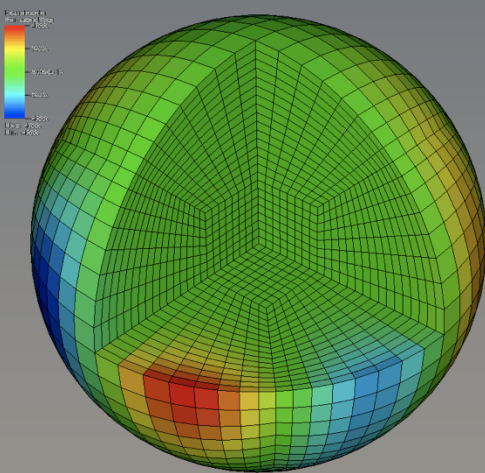


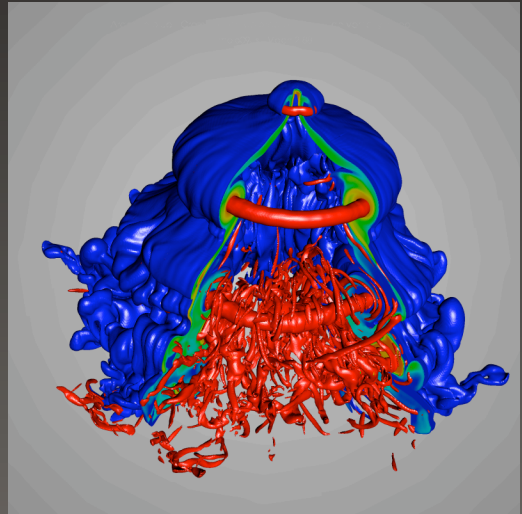
Visualization of Adaptive Mesh Refinement Data with VisIt

Gunther H. Weber

Lawrence Berkeley National Laboratory

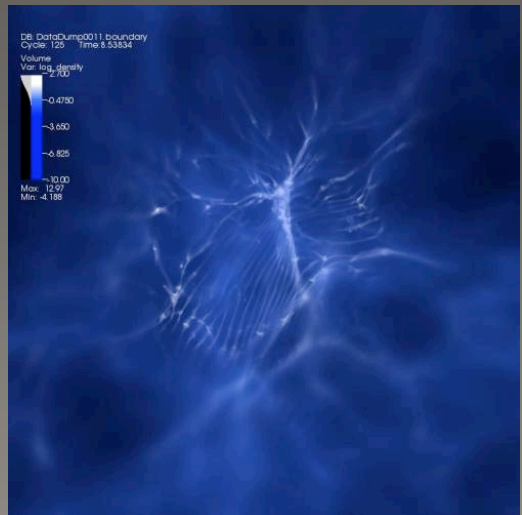


- Richly featured visualization and analysis tool for large data sets
- Built for five use cases:
 - Data exploration
 - Visual debugging
 - Quantitative analysis
 - Presentation graphics
 - Comparative analysis
- Data-parallel client server model, distribution on per patch-basis
- Use of meta-data / contracts to reduce amount of processed data



[Argon bubble subjected to shock Jeff Greenbough, LLNL]

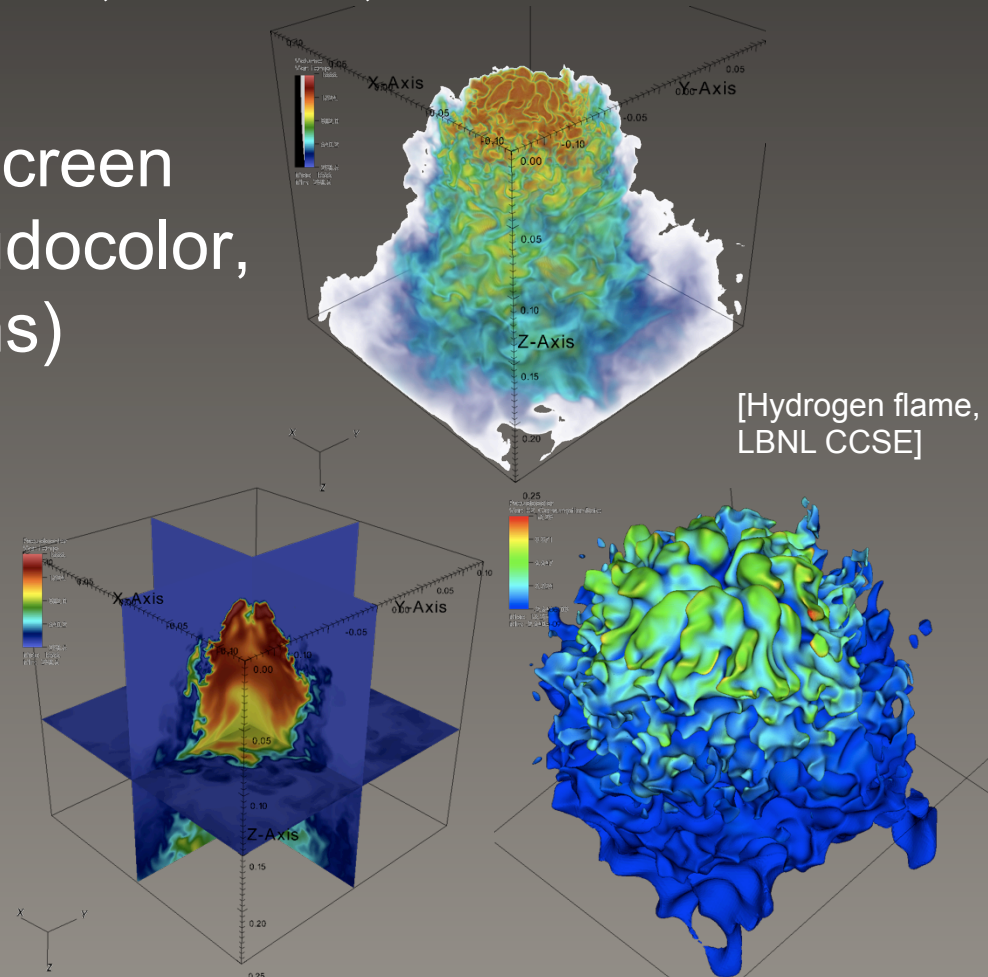
➔ Ideal basis for specialized AMR visualization tool replacement



[Logarithm of gas/dust density in Enzo star/galaxy simulation, Tom Abel & Matthew Turk, Kavli Institute]

VisIt Concepts (1/2)

- **Databases:** Implementation of various file formats, e.g., Chombo, Boxlib, Enzo, FLASH, ...
- **Plots:** Display data on screen (volume rendering, pseudocolor, isosurface, vector glyphs)
- **Operators:** Filter data before it is displayed (slice, isosurface, clip, displace, ...)



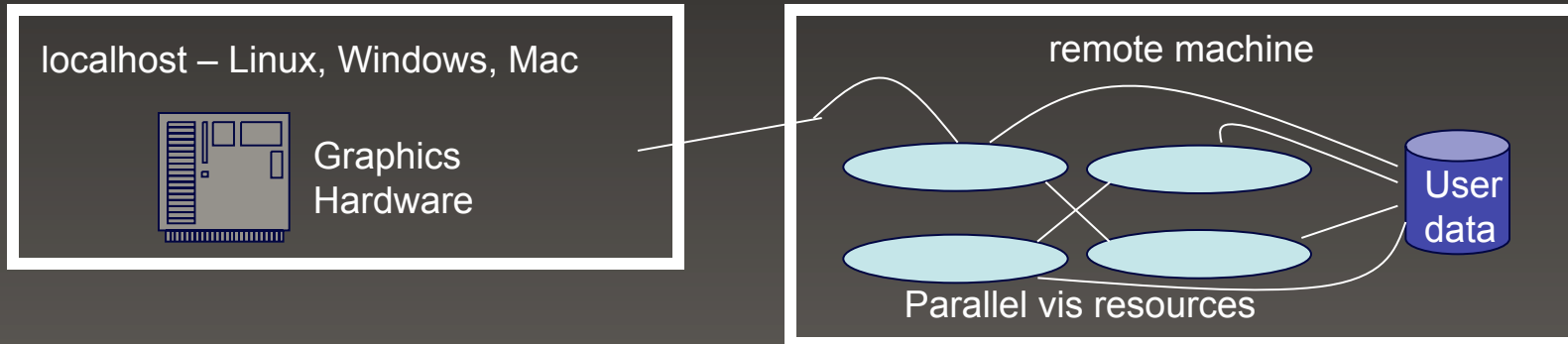
VisIt Concepts (2/2)

- **Expressions:**
 - Create new variables from existing ones via arithmetic expressions: +, -, *, /, dot product, cross product, ...
 - Conditionals and comparisons
 - Import variables from different time steps or simulations
 - Other operations: image processing (smoothing), connected components of isosurfaces, ...
- **Picking:** Get information (value, location in mesh) for a given “point” in a visualization
- **Queries:** High-level information (area, volume, integral of variable, number of connected components, ...) coupled with ability to create curve of quantity over time

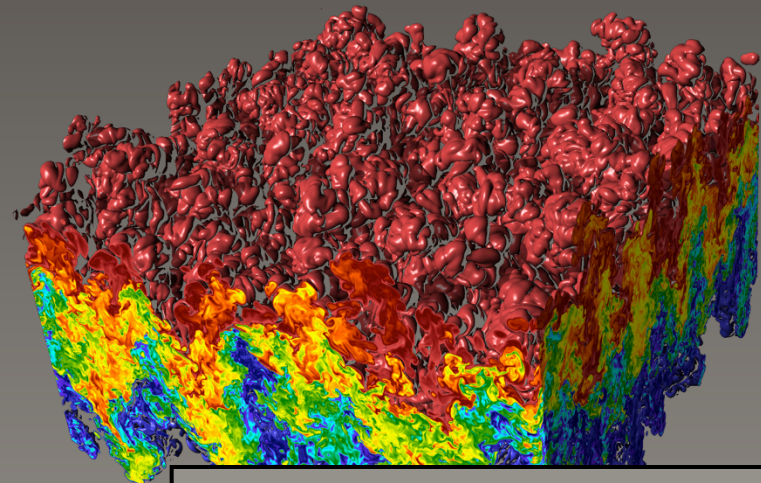
VisIt Capabilities

- **Meshes:** rectilinear, curvilinear, unstructured, point, AMR
- **Data:** scalar, vector, tensor, material, species
- **Dimension:** 1D, 2D, 3D, time varying
- **Rendering (~15):** pseudocolor, volume rendering, hedgehogs, glyphs, mesh lines, etc...
- **Data manipulation (~40):** slicing, contouring, clipping, thresholding, restrict to box, reflect, project, revolve, ...
- **File formats (~85)**
- **Derived quantities:** >100 interoperable building blocks
+, -, *, /, gradient, mesh quality, if-then-else, and, or, not
- **Many general features:** position lights, make movie, etc
- **Queries (~50):** ways to pull out quantitative information, debugging, comparative analysis

VisIt's Parallelized Client-Server Architecture.



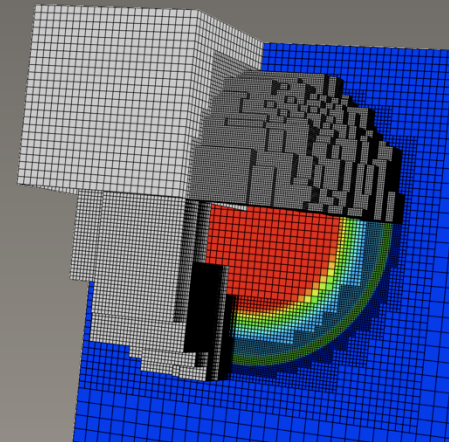
- Client-server observations:
 - Good for remote visualization
 - Leverages available resources
 - Scales well
 - No need to move data




27B element Rayleigh-Taylor Instability (MIRANDA, BG/L)

VisIt and AMR Data

- Supported as “first-class” data type
- VisIt understands:
 - Nesting of patches / Boundaries between patches
- Strategy:
 - Each patch is processed separately
 - After reading data, subsequent passes to:
 - Identify coarse elements that are refined and mark them as “ghost”
 - Create ghost layers around outer boundaries (needs work)
 - Work on rectilinear grids and skip ghost cells or “remove” results produced in ghost cells later on
- UI:
 - Color by patch, color by level
 - Remove / show patches, levels
 - Have appropriate info returned for picks



Visual Spreadsheets

- Significance:
 - Essential debugging tool for code development teams
 - Support inspecting values in individual cells
 - Available in ChomboVis (ANAG) and AMRVis (CCSE)
- Development:
 - Implemented ChomboVis version of visual spreadsheets
 - Linked spreadsheets to VisIt's "pick" capability 
 - Mark picked points in 2D/3D visualization view (existing VisIt capability) and spreadsheet to indicate correlation
 - Double precision data available in spreadsheet plots

Visual Spreadsheets – Example

Spreadsheet – phi0: level0_patch0

3D
j=15 [0,0]

Normal X Y Z

Display
Format %1.6f
 Color hot_desaturatec
 Show tracer plane

j=15

i	k=3	k=4	k=5	k=6	k=7	
i=27	8	-0.001438	-0.001869	-0.002314	-0.002771	-0.003121
i=26	5	-0.001776	-0.002314	-0.002872	-0.003446	-0.004021
i=25	6	-0.002121	-0.002771	-0.003446	-0.004138	-0.004837
i=24	8	-0.002471	-0.003234	-0.004026	-0.004837	-0.005625
i=23	0	-0.002819	-0.003694	-0.004600	-0.005525	-0.006460
i=22	5	-0.003157	-0.004138	-0.005153	-0.006186	-0.007271
i=21	6	-0.003474	-0.004554	-0.005667	-0.006799	-0.007980
i=20	7	-0.003759	-0.004926	-0.006127	-0.007346	-0.008622
i=19	8	-0.004003	-0.005242	-0.006517	-0.007808	-0.009170
i=18	3	-0.004194	-0.005491	-0.006822	-0.008170	-0.009525
i=17	7	-0.004327	-0.005662	-0.007032	-0.008419	-0.009819
i=16	5	-0.004394	-0.005749	C=-0.007140	-0.008545	-0.009946
i=15	5	-0.004394	-0.005749	B=-0.007140	E=-0.008545	-0.009946
i=14	7	-0.004327	-0.005662	A=-0.007032	D=-0.008419	-0.009819
i=13	3	-0.004194	-0.005491	-0.006822	-0.008170	-0.009525
i=12	8	-0.004003	-0.005242	-0.006517	-0.007808	-0.009170
i=11	7	-0.003759	-0.004926	-0.006127	-0.007346	-0.008622
i=10	6	-0.003474	-0.004554	-0.005667	-0.006799	-0.007980
i=9	5	-0.003157	-0.004138	-0.005153	-0.006186	-0.007271
i=8	0	-0.002819	-0.003694	-0.004600	-0.005525	-0.006460
i=7	8	-0.002471	-0.003234	-0.004026	-0.004837	-0.005625
i=6	6	-0.002121	-0.002771	-0.003446	-0.004138	-0.004837
i=5	5	-0.001776	-0.002314	-0.002872	-0.003446	-0.004021
i=4	8	-0.001438	-0.001869	-0.002314	-0.002771	-0.003121
i=3	5	-0.001108	-0.001438	-0.001776	-0.002121	-0.002471
i=2	7	-0.000785	-0.001018	-0.001255	-0.001496	-0.001741
i=1	3	-0.000468	-0.000607	-0.000747	-0.000890	-0.001039
i=0	1	-0.000156	-0.000202	-0.000248	-0.000295	-0.000341

Variable phi0
Min = -0.017083 Max = 0.000000

Window 1

Pick

poissonOut.hdf5.gz timestep 0
Mesh level 0 patch level0_patch0
Point: <0.485135, 0.500000, 0.200573>
Zone: 6639
Incident Nodes: 7044 7045 7077 7078 8133 8134
8166 8167
phi0: <zonal> = -0.00854513

Max Tabs 8 Save Picks as...

Variables default

Concise Output.
 Show Mesh Name Show Timestep
 Display incident nodes/zones.
 Display global nodes/zones.
 Display reference pick letter.

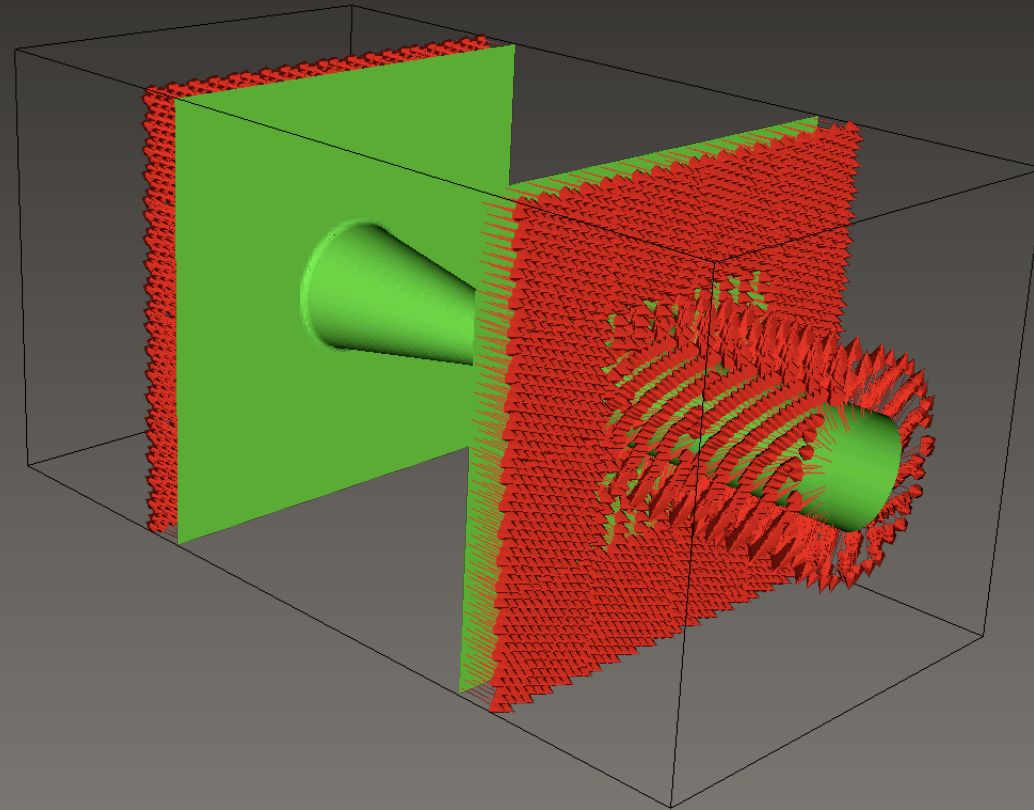
Display for Nodes:
 Id Domain-Logical Coords
 Physical Coords Block-Logical Coords

Display for Zones:
 Id Domain-Logical Coords
 Block-Logical Coords

Automatically show window
 Don't clear this window
 Create time curve with next pick.
 Create spreadsheet with next pick.

Make default Reset
Apply Post Dismiss

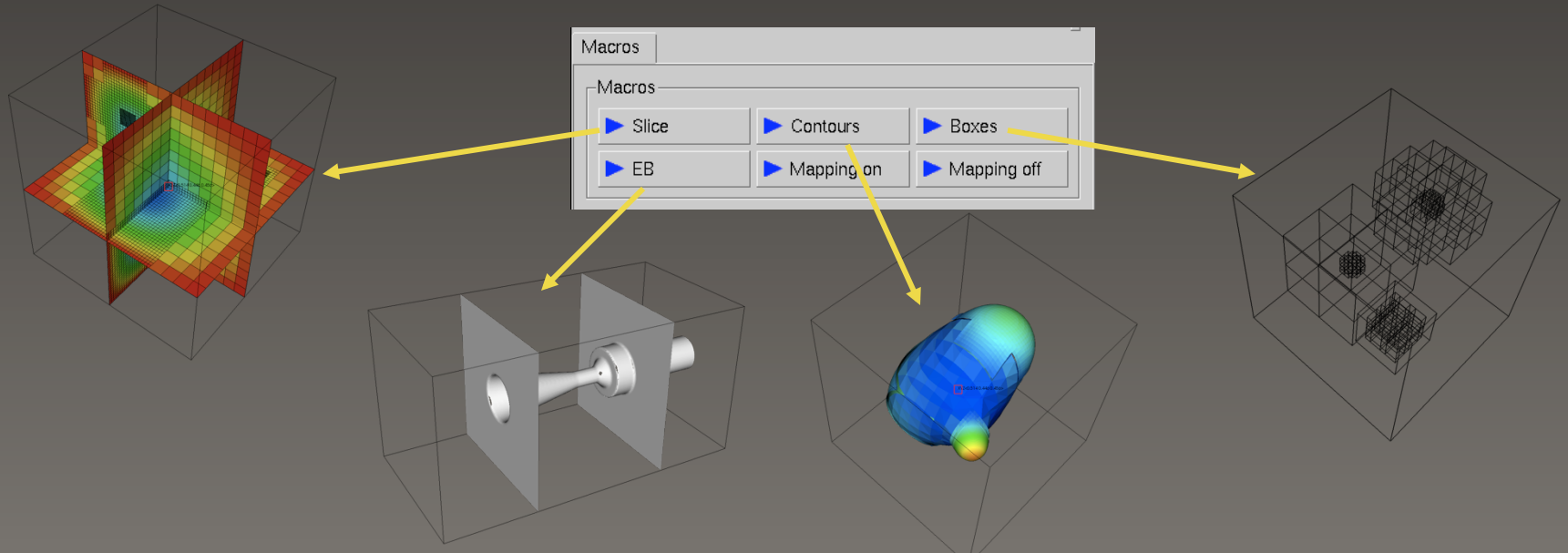
Basic Embedded Boundary Support for Chombo Files



- Convert embedded boundary information contained in Chombo files to VisIt's internal representation
- Embedded "Boundary" Operator

Easing the Transition from ChomboVis

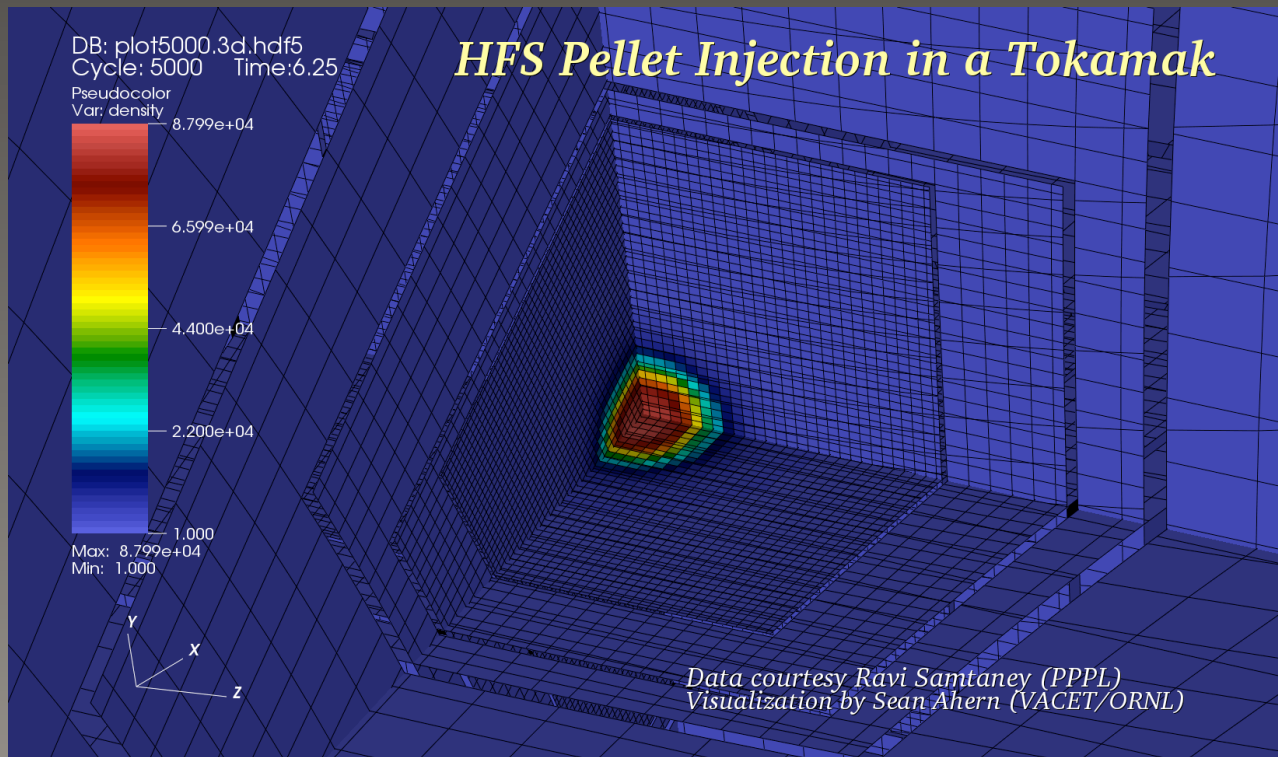
- Wrote macros to ease transition of Applied Numerical Algorithms Group to VisIt



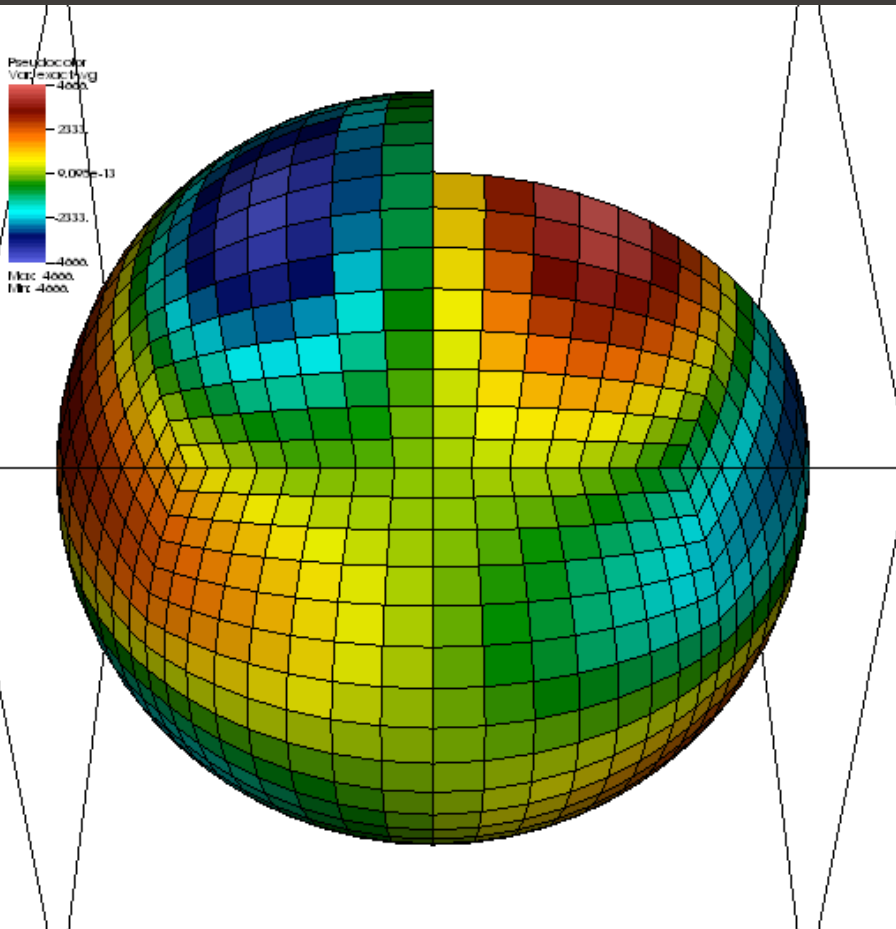
- Customized setting for ANAG / APDEC collaborators, e.g.,
 - Show only root level by default
 - Show only explicit materials

Mapped Grids – Analytical Mapping

- Functionality beyond ChomboVis capabilities
- VisIt already supported analytical mappings via expressions and “Displacement” operator
- Issue: Cell centered data vs. vertex centered mapping

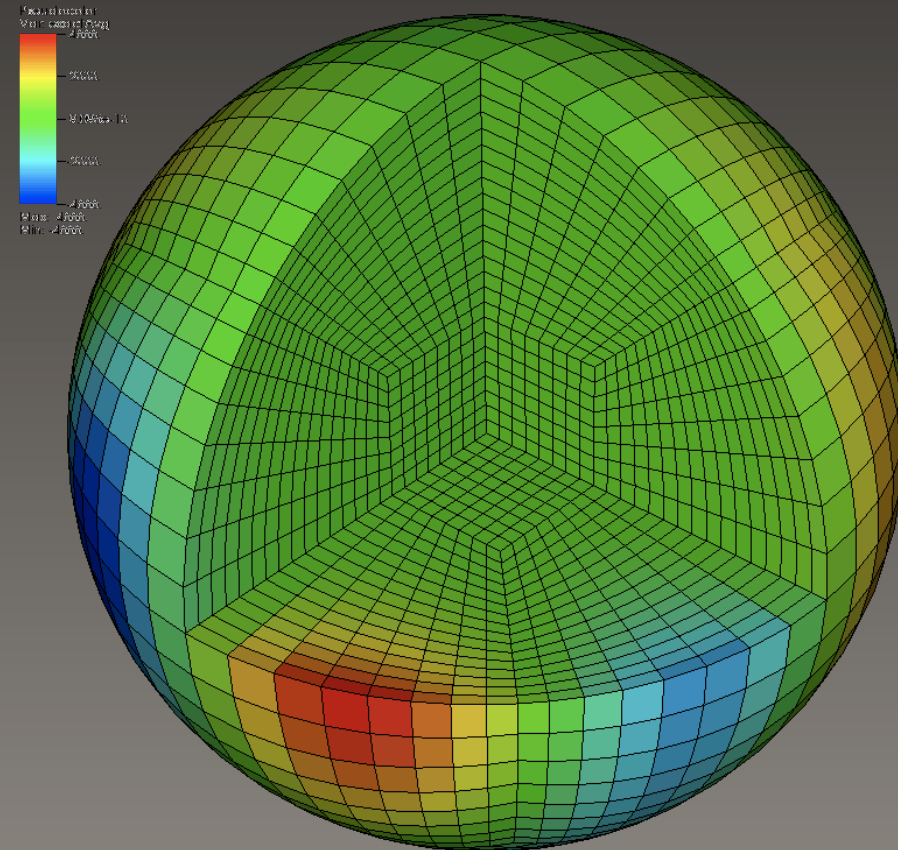
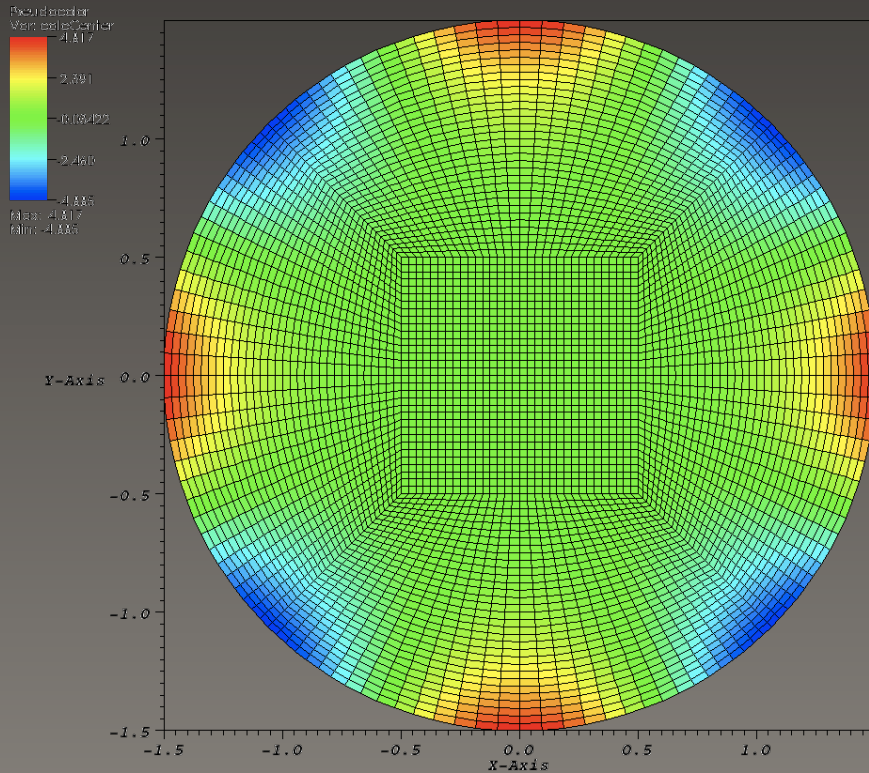


Mapped Grids – Arbitrary Mapping




- Analytical mapping not sufficiently flexible, e.g., different maps for different boxes
- Chombo:
 - No file format for mapped grids
 - Current Chombo files either node or cell centered
- ➔ Workaround with two Chombo files and “conn_cmfe” expression
- Automated via “visitrc” macros tying it all together (e.g., AddPlot callback)

Mapped Grids – Examples

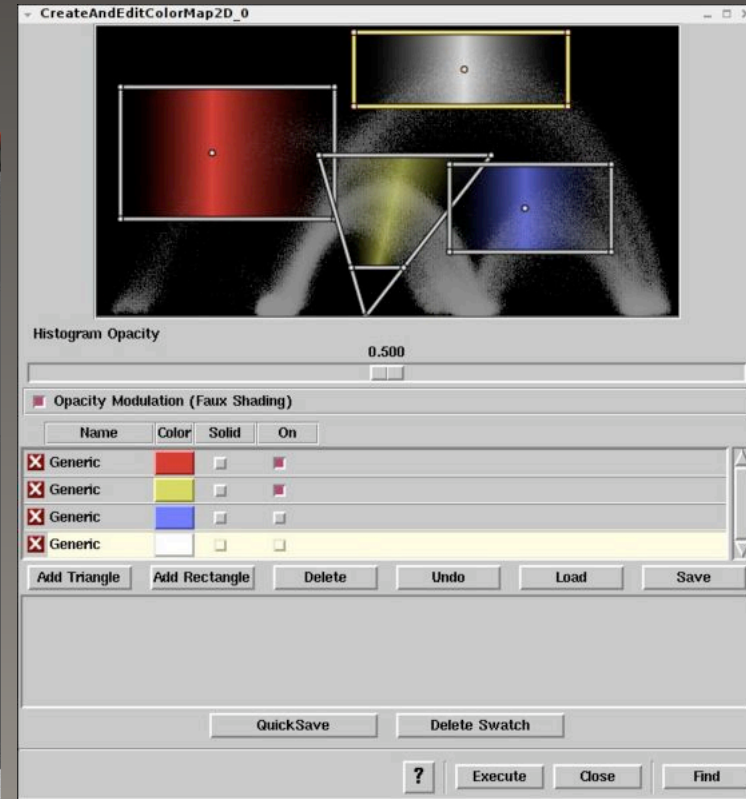
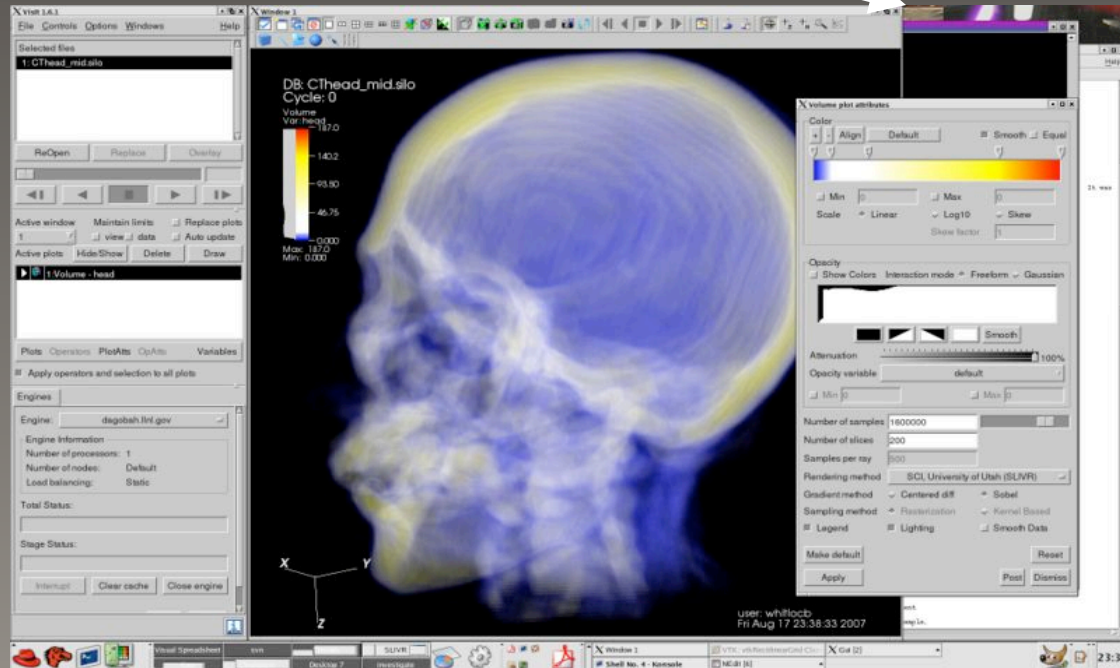


Improved Volume Rendering (Utah SCI Institute SLIVR)

- High-quality volume rendering library developed by the SCI Institute at the University of Utah
- Multidimensional transfer functions

In progress 

Implemented (VisIt 1.9) 



Outlook: Future VisIt Extensions (Work in Progress)

- Fully integrate SLIVR and add hardware-accelerated AMR volume rendering without resampling
- Improve VisIt's streamline capabilities
 - Parallel streamline computation
 - Streamlines that cross patch/box boundaries
 - Streamlines as “building blocks” for higher-level visualization/analysis techniques (stream surfaces etc.)
 - AMR-aware streamlines
- Improve Embedded Boundary (EB) / Material Interface Reconstruction (MIR) support
- Improve double precision support (expressions, select set of plots)
- Crack-free isosurfaces

Becoming more Open Source-y Project and Forming a Supporting Community

- Moved from ClearCase to Subversion
 - Previously only LLNL folks could develop
 - Checkin every 3.85 hours over last 7 months
- Bug tracking still at LLNL, need to move to Gforge.
- Mailing lists transitioned to ORNL.
 - Visit-help → visit-users
 - Will be searchable.
- Wiki (<http://visitusers.org>) for users and developers
 - 200+ pages of content
- Reducing barriers for new developers
 - Renaming of many modules to reduce barriers for new developers
 - Wiki documents “-debug”, “-dump”, memory leaks detection, how to do memory management, design of code, etc.

Questions?



VACET

