

Visualize This: Lessons from the Front-lines of High Performance Visualization

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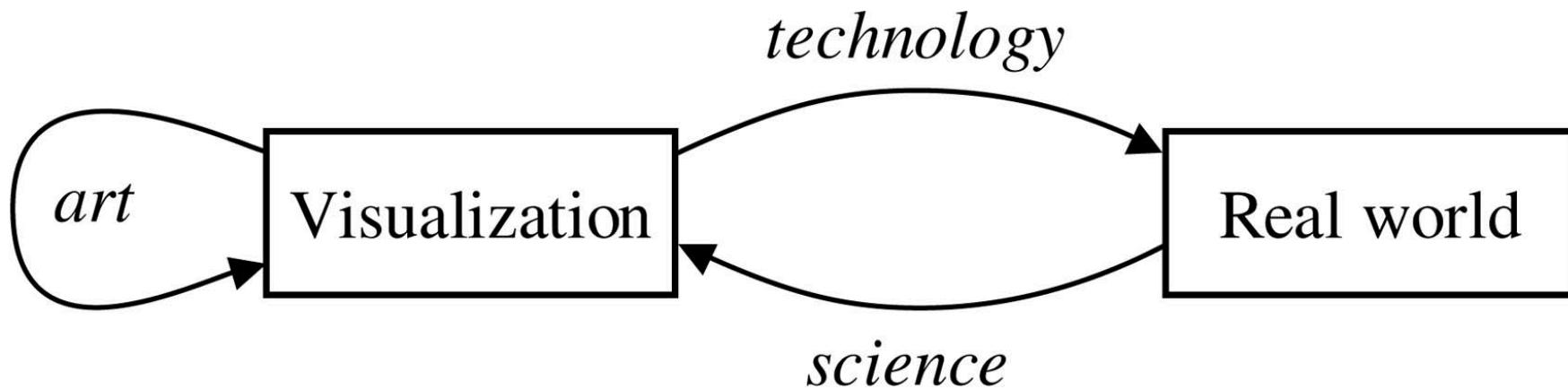
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Views on visualization



(Van Wijk ,2006)

Visualization taxonomy

- Scientific Visualization
 - Using interactive visual representation of scientific data to amplify cognition
 - Typically has spatial components
- Information Visualization
 - Using interactive visual representations of abstract, non-physical based data to amplify cognition
 - No spatial components typically

(Card et al. , 1999)

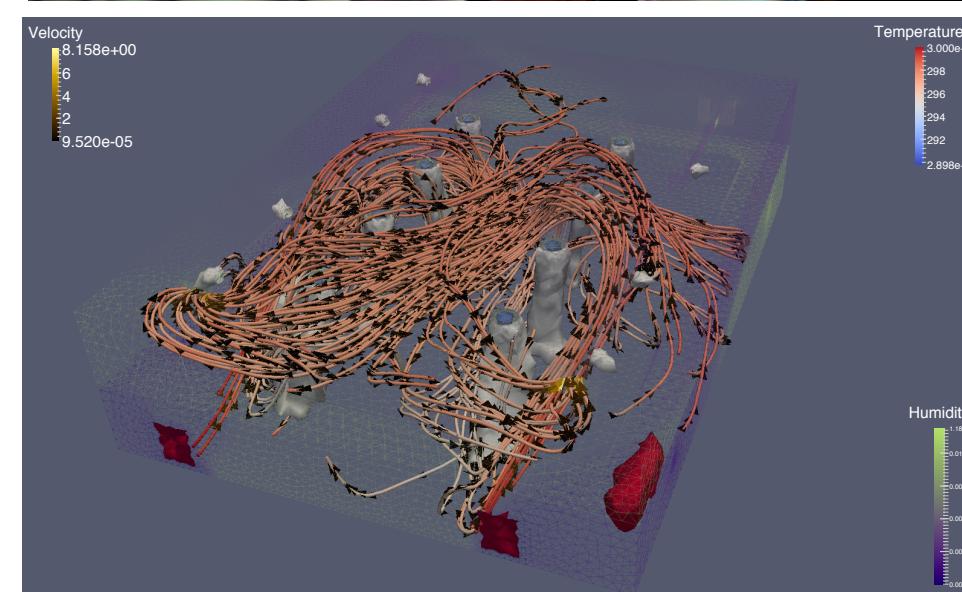
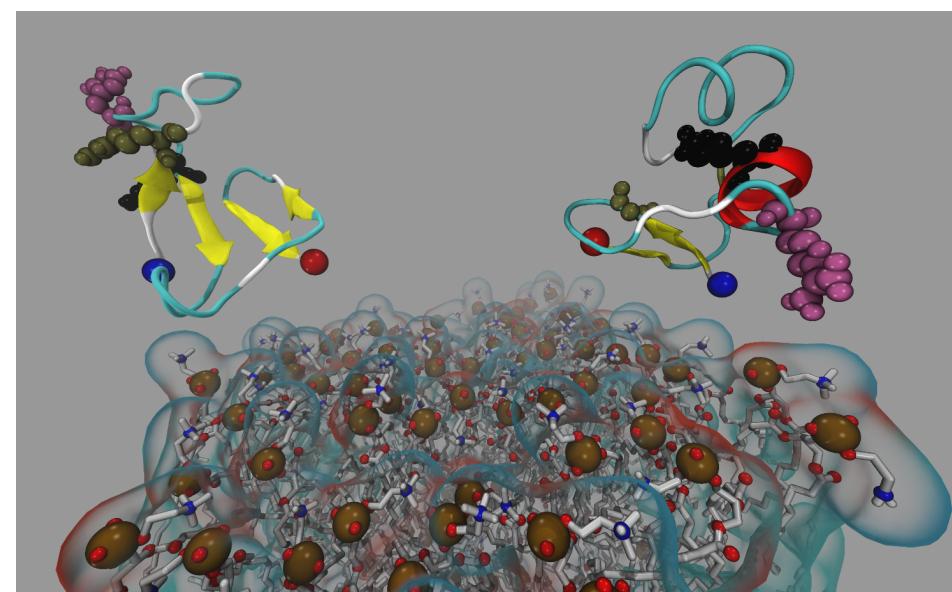
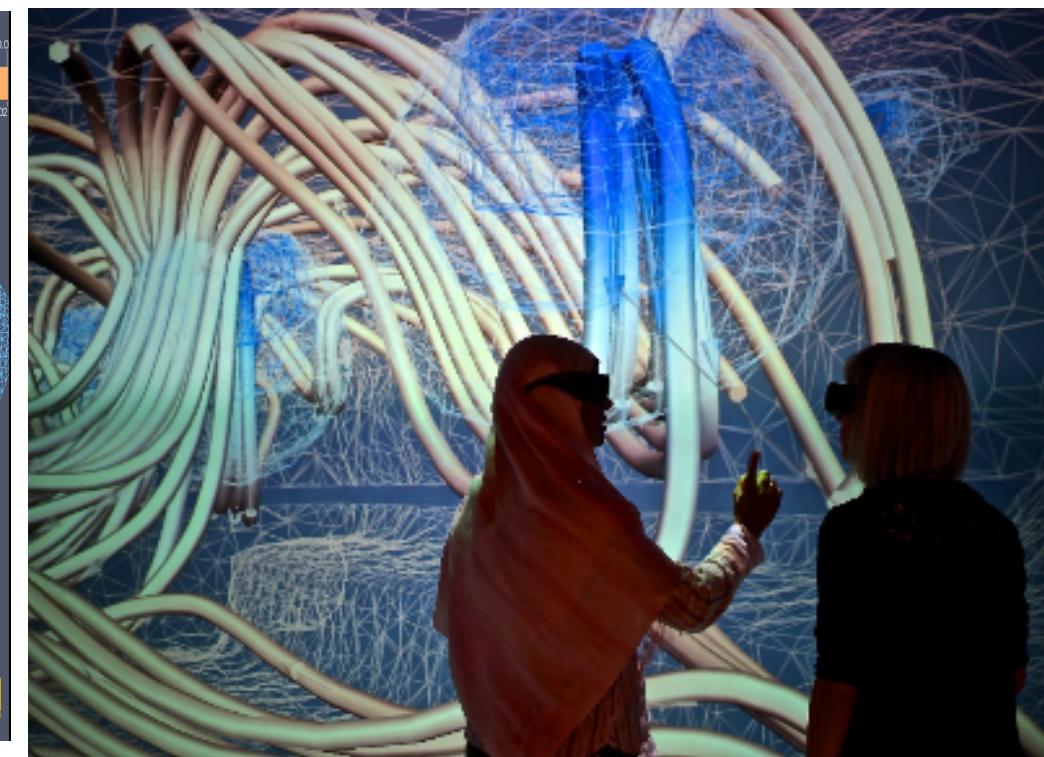
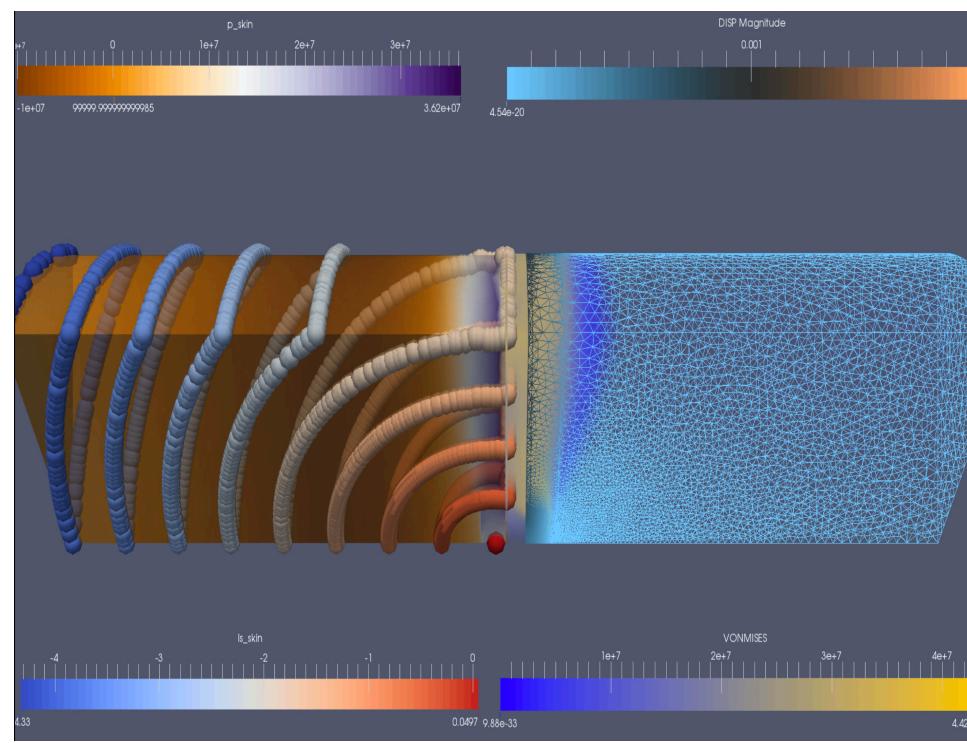
Scientific Visualization

- $x_i = (x_{i1}, \dots, x_{im})$
- Visual Discrimination
- Humans have predictable bias in:
 - Interpreting visual-spatial information
 - Making inferences
 - Understanding relationships over time
- Mapping numerical data to 'ordered' visual elements:
 - Position
 - Size
 - brightness
- Mapping nominal data (names and categories) to 'unordered' visual elements:
 - shape
 - color
- HPC: remote parallel processing and visualization of large-scale datasets

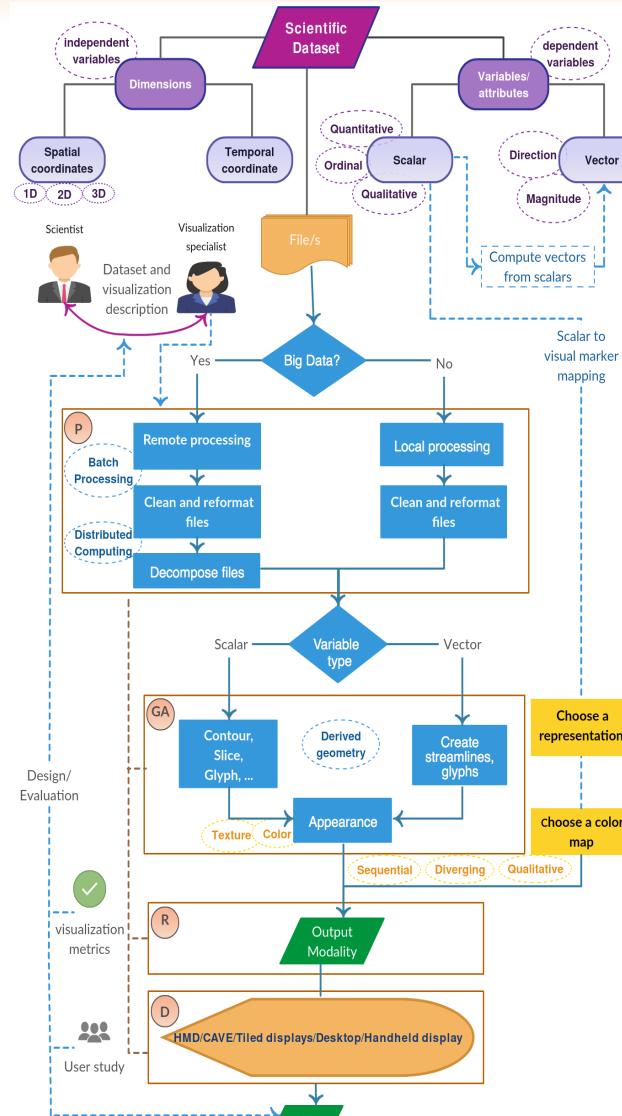
High Performance Visualization

- Intel Xeon E5-2680 v3 @ 2.5GHz
- Cores: 24, multi-threaded Memory: 512G
- Graphics: Nvidia Quadro M6000 x 4
- Resolution: 2560x1600
- Frequency: 120Hz
- Active Stereo
- Contrast Ratio: 5300:1
- Aspect Ratio: 16:1
- 3 three 10'x 10' Walls and a floor, 2 projectors per each
- Tracking System – Intersense IS900 driving a head & a wand
- ParaView-cave, VRPN
- Different Clients can collaborate in the same session





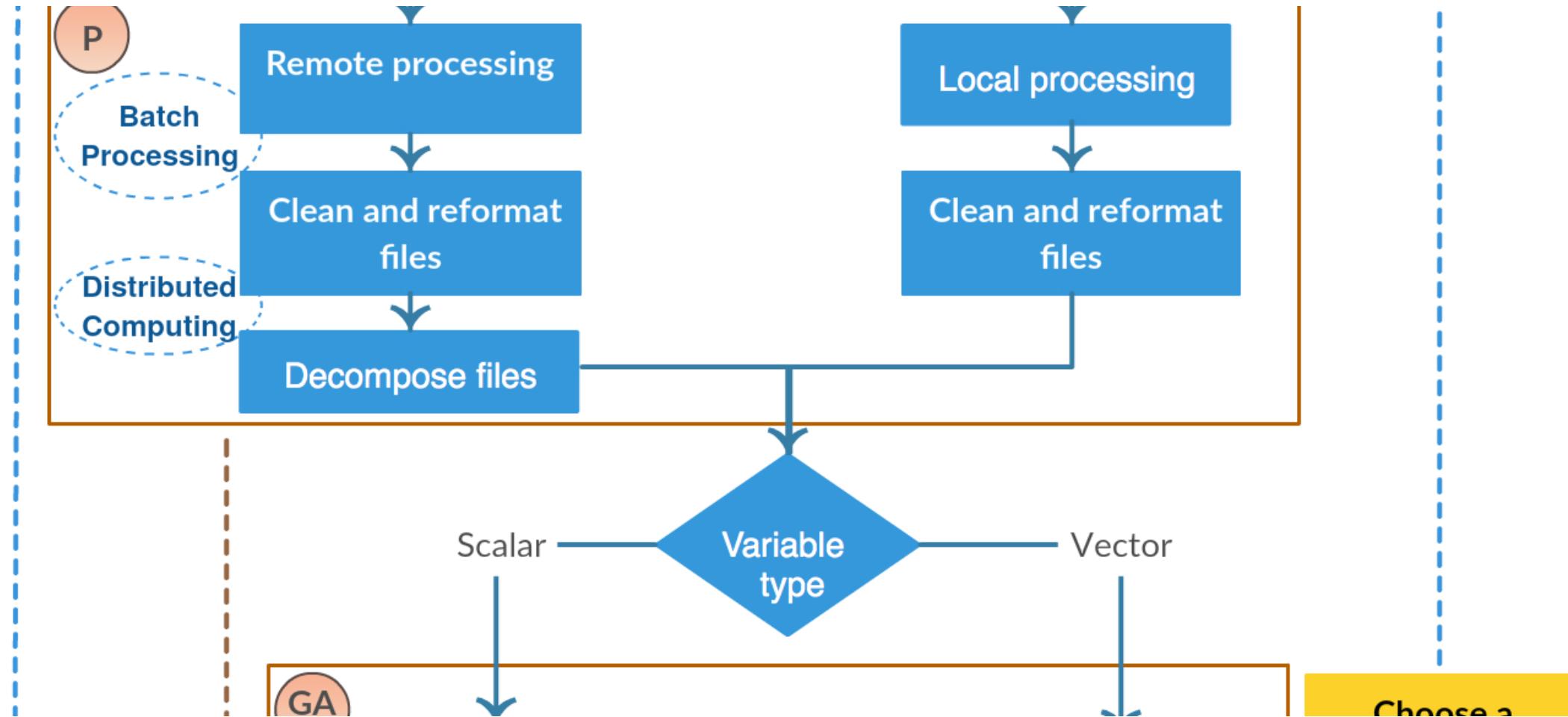
Scientific Visualization Paradigm



Scientific Visualization Paradigm(Cont'd)

- $F(N, T) \xrightarrow{C} V$
- N: Number of dimensions
- T: (data)Type [scalar, vector]
- C = {GA U R U D}
- P: Processing [serial, parallel, local, in situ, remote]
- GA: Geometric and Appearance properties [streamlines, glyphs, contours ,slices, color maps, texture maps, ...]
- R: Rendering [still scenes, animations, 3D worlds, auditory, haptic, ...]
- D: Display ["handheld", "desktop", "tiled displays", "immersive", "..."]
- V is the resulting visualization

Scientific Visualization Paradigm(Cont'd)



Preprocessing and Rendering

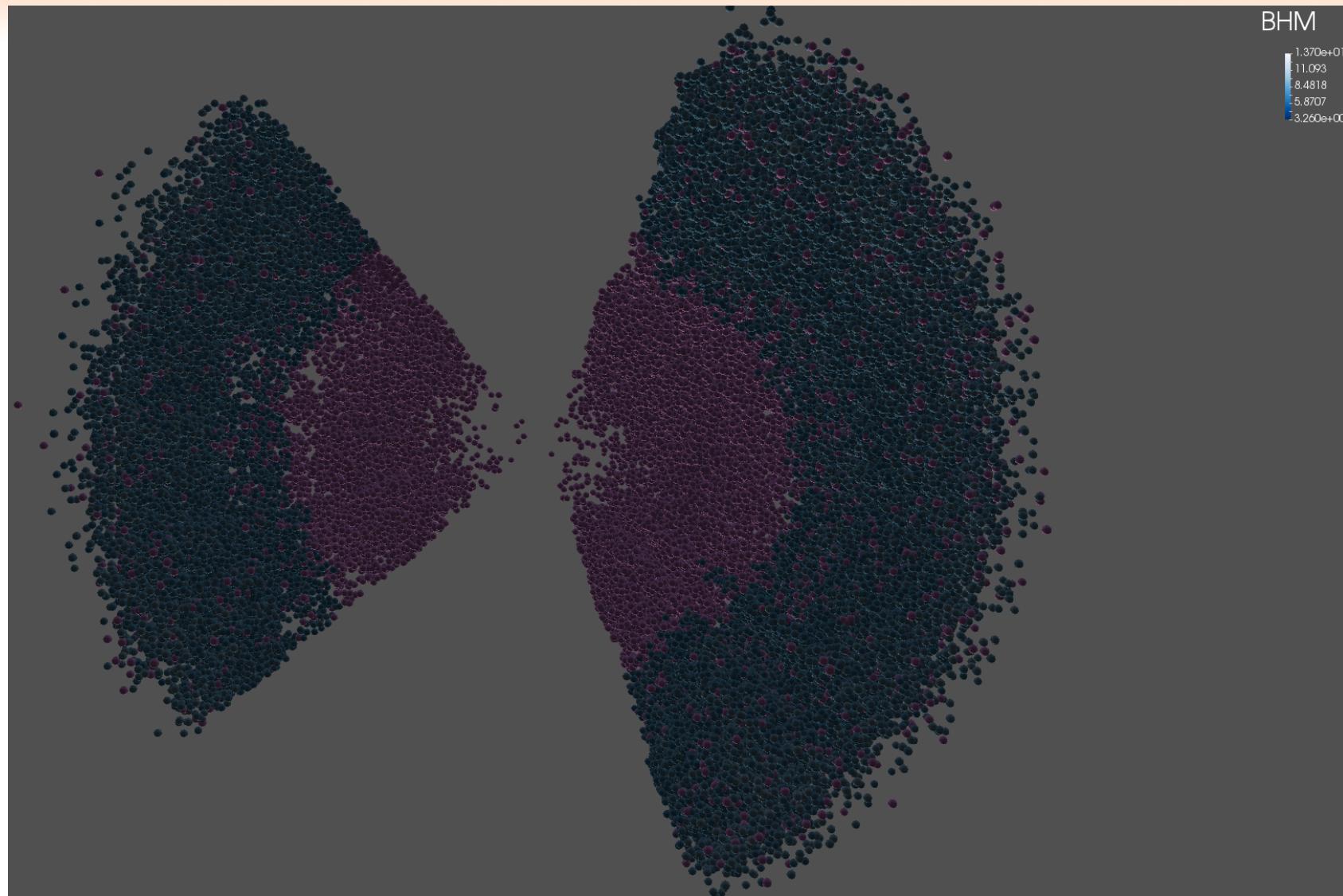
- Preprocessing (P)
 - Serial or Parallel
 - ParaView with Python scripting can be used
- Rendering
 - local, in-situ, or remote
 - ParaView with OSPRay enabled(realistic scene)

Output Modality and Display

- Still scenes (2D images, 3D scenes)
- Auditory and haptic feedback
- Handheld
- Desktop display
- Display Wall
- HMD or in a CAVE

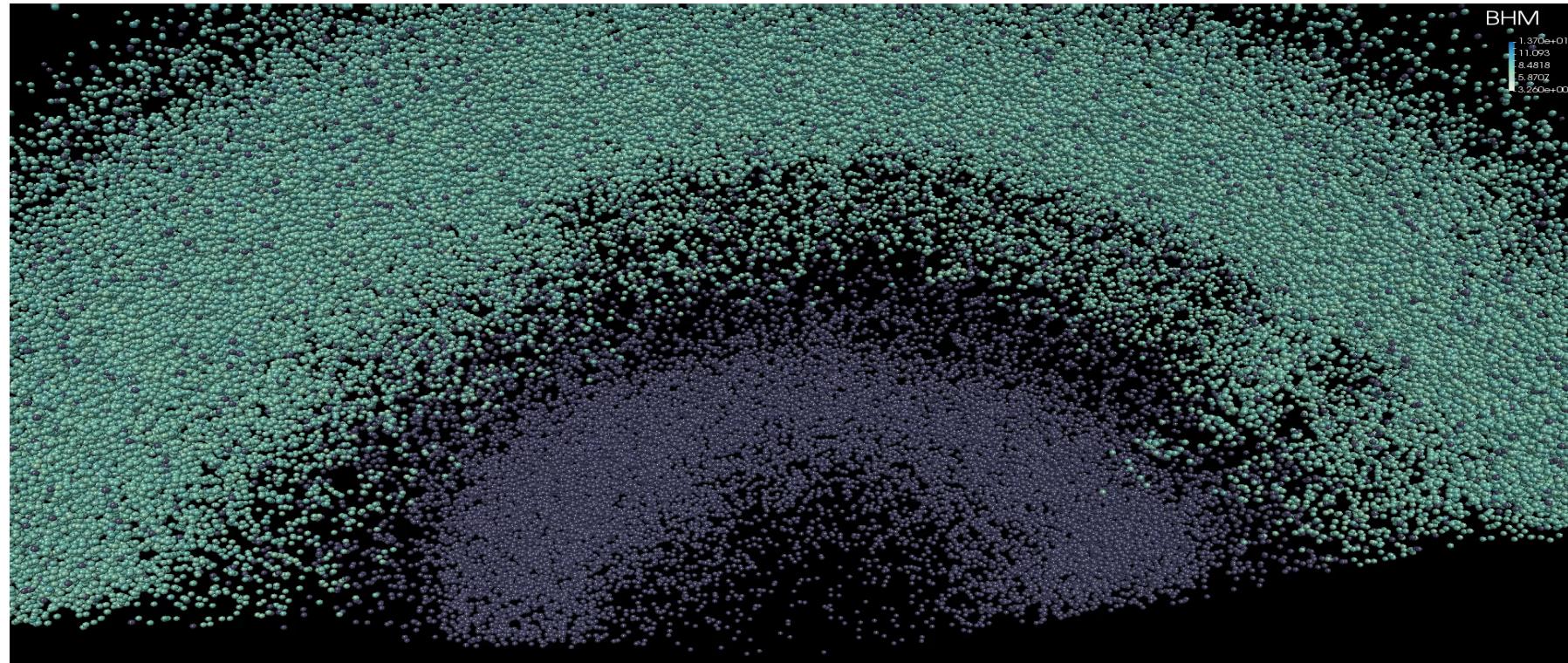
Galaxy Assembly in Virtual Reality

- 166,583 galaxies visualization
 - Obtained from the Sloan Digital Sky Survey
 - The quasars are found across 10,000 degrees of the sky
 - All have known distances via their redshifts
 - Catalog includes 139 attributes of meta-data for each quasar: luminosities, masses, and kinematic properties
- (Pâris et al. 2012)



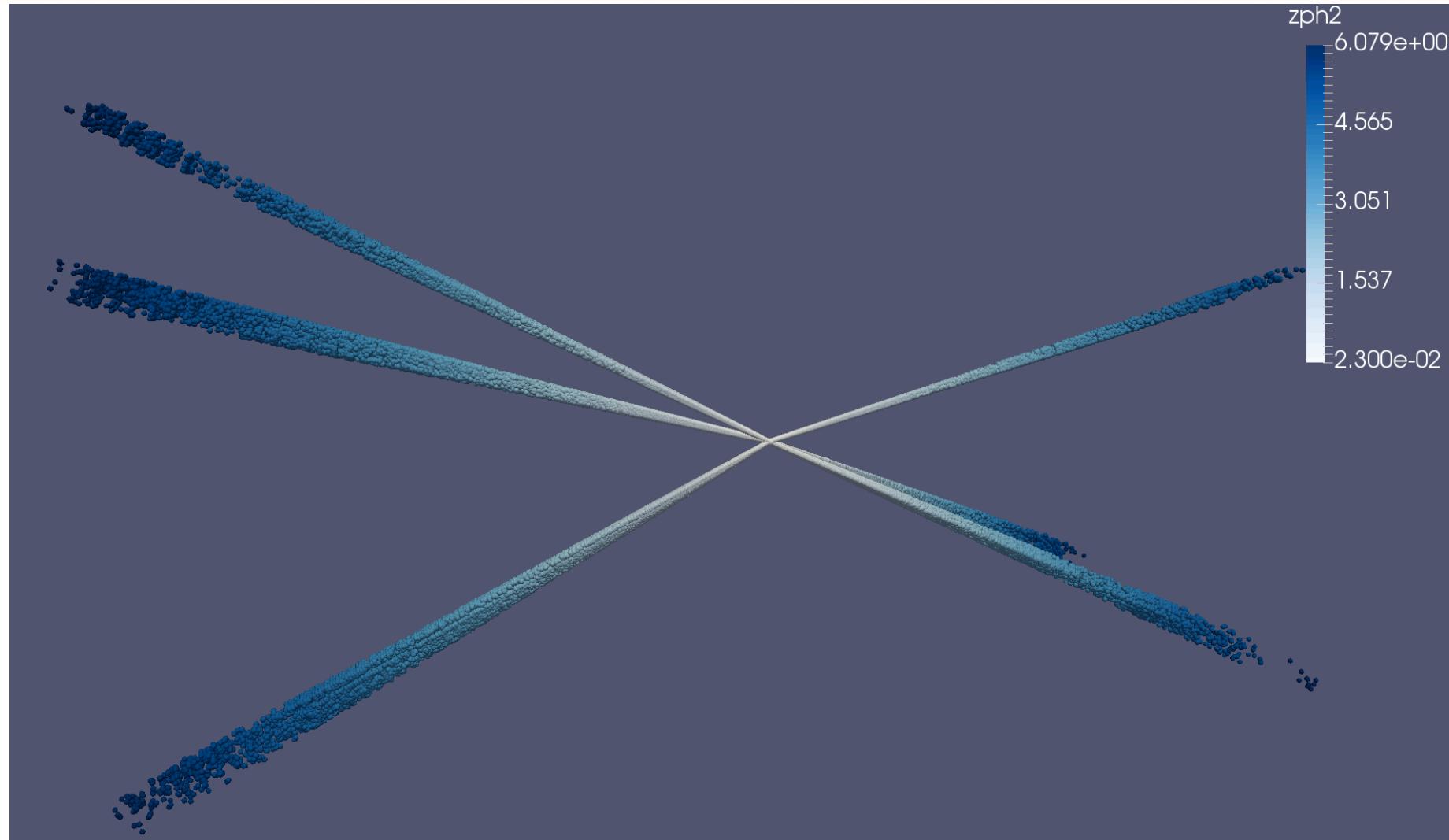
Galaxy Assembly in Virtual Reality

- 3-dimensions
- ~ 130-variables
- Single processor
- ParaView on-site rendering
- Single scene
- Animation
- Immersive



Galaxy Assembly in Virtual Reality

- 1,000,000 galaxies visualization
- Infrared imaging observations
- 80 attributes of meta-data
- Found in 6 widely separated fields on the sky
- Known positions of the galaxies on the sky
- Distances via redshifts have Significant uncertainties
(Rowan-Robinson et al. 2013)



Galaxy Assembly in Virtual Reality

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Galaxy Assembly in Virtual Reality

- The third is a catalog of $\sim 1,200,000,000$ stars
- Gaia mission
- Measure of each star's position on the sky, distance, encoded via parallax
- There is less meta-data per source for this catalog
- but the challenge is to show the spatial distribution of all the stars

TACC Resources

- Stampede2: comparisons of previously performed simulations with gravitational wave data observed by the NSF-funded Laser Interferometer Gravitational-Wave Observatory (LIGO)
- Future:
 - In-situ visualization
 - Interactive visual analytics using VR

Evaluation and Feedback

- Designing user studies: sensory discrimination tasks
 - On-site experiments
 - Online Surveys
- Calculating visualization metrics
 - Effectiveness
 - Expressiveness
 - Readability
 - Cost

Visualization metrics

- Effectiveness: How many objects of the data set can be included in the visualization
- Expressiveness: Which variables of an MVMD are shown in the visualization
- Readability: The human's strength and weakness to perform perceptual discrimination tasks
- Cost: Computational and man-hours cost
- aesthetical & perceptual aspects