Introduction to Inviwo

free configurable visualizations for scientific data

Martin Falk

MAX IV, Lund 2024

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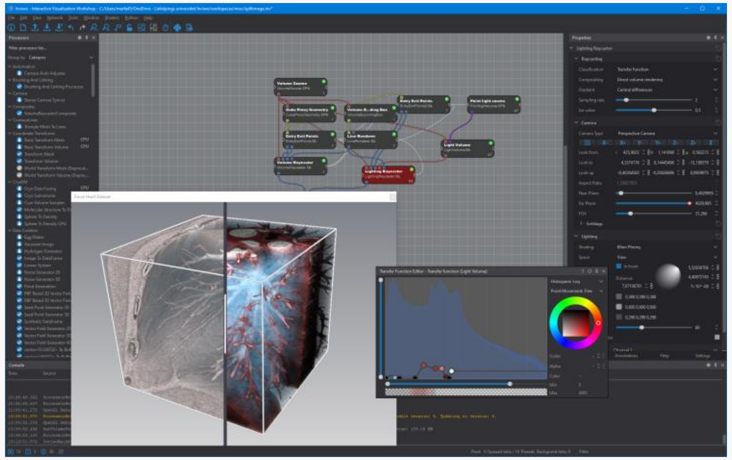
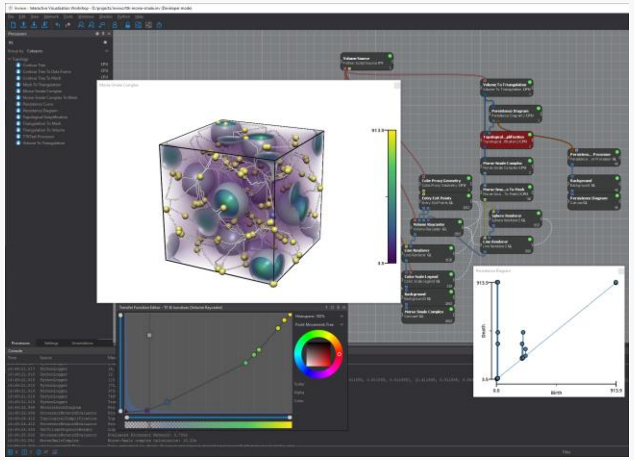
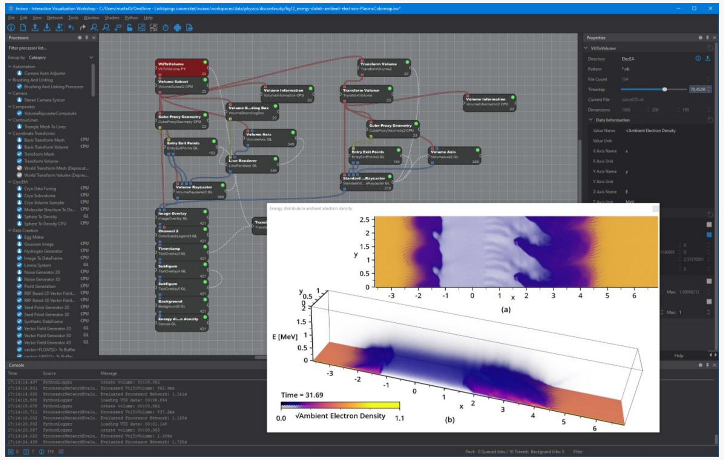
Swedish e-Science Research Centre

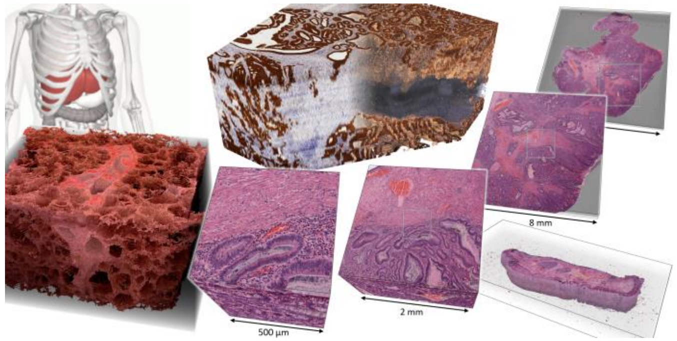
ELLIIT

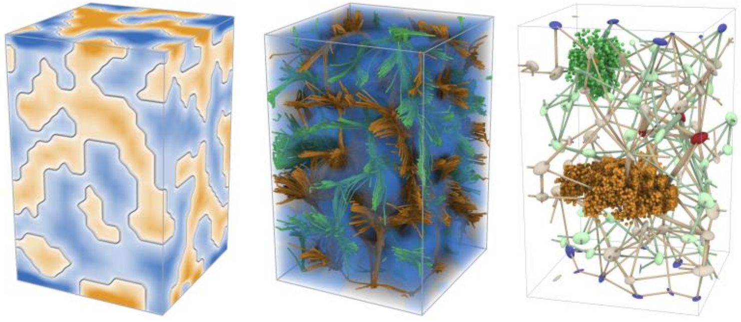
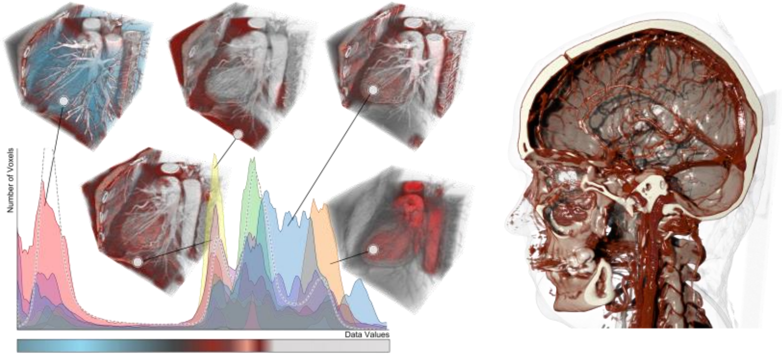
InfraVis

Visualization configuration

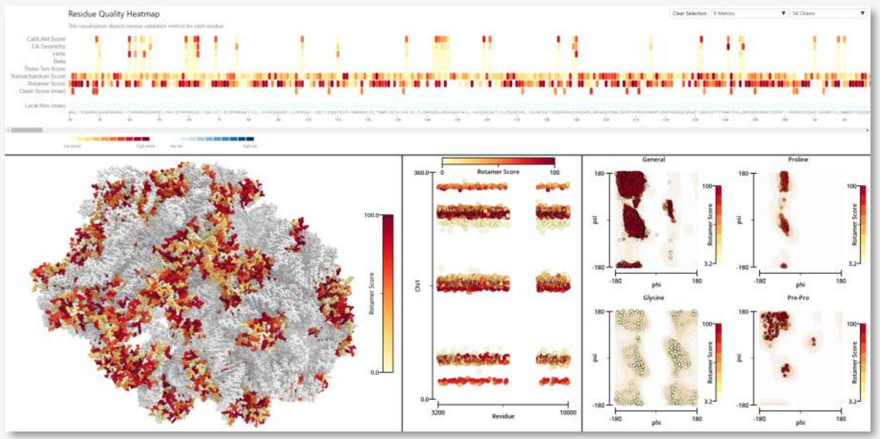




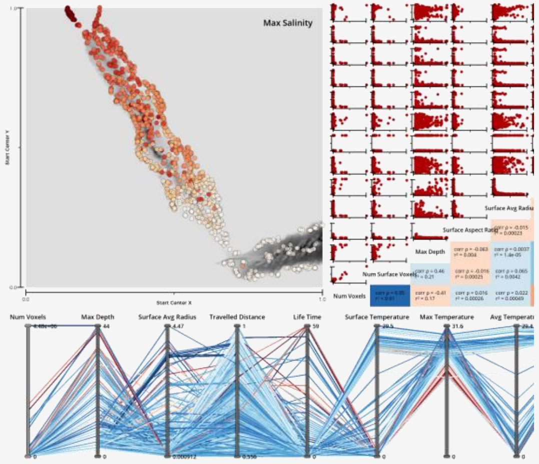
Results for publications

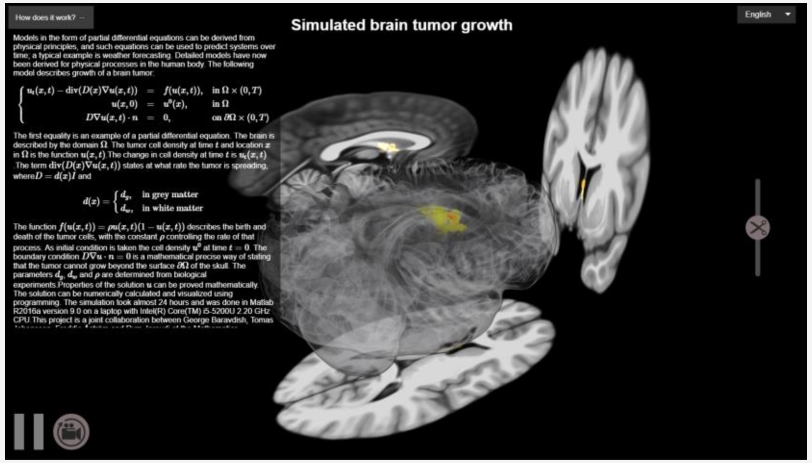


Applications







Models in the form of partial differential equations can be derived from physical principles, and such equations can be used to predict systems over time; a typical example is weather forecasting. Detailed models have now been derived for physical processes in the human body. The following model describes growth of a brain tumor:

$$\begin{cases} u_t(x,t) - \mathrm{div}(D(x)\nabla u(x,t)) = f(u(x,t)), & \text{in } \Omega \times (0,T) \\ u(x,0) = u^0(x), & \text{in } \Omega \\ D\nabla u(x,t)\cdot n = 0, & \text{on } \partial\Omega \times (0,T) \end{cases}$$

The first equality is an example of a partial differential equation. The brain is described by the domain Ω. The tumor cell density at time t and location x in Ω is the function $u(x,t)$.The change in cell density at time t is $u_t(x,t)$ .The term $\mathrm{div}(D(x)\nabla u(x,t))$ states at what rate the tumor is spreading, where$D = d(x)I$ and

$$d(x) = \begin{cases} d_g, & \text{in grey matter} \\ d_w, & \text{in white matter} \end{cases}$$

The function $f(u(x,t)) = \rho u(x,t)(1-u(x,t))$ describes the birth and death of the tumor cells, with the constant ρ controlling the rate of that process. As initial condition is taken the cell density u^0 at time $t = 0$. The boundary condition $D\nabla u \cdot n = 0$ is a mathematical precise way of stating that the tumor cannot grow beyond the surface $\partial\Omega$ of the skull. The parameters d_g, d_w and ρ are determined from biological experiments.Properties of the solution u can be proved mathematically. The solution can be numerically calculated and visualized using programming. The simulation took almost 24 hours and was done in Matlab R2016a version 9.0 on a laptop with Intel(R) Core(TM) i5-5200U 2.20 GHz CPU.This project is a joint collaboration between George Baravdish, Tomas

Inviwo

Research software

Developed by Visualization groups at

- LiU, UULM, and KTH

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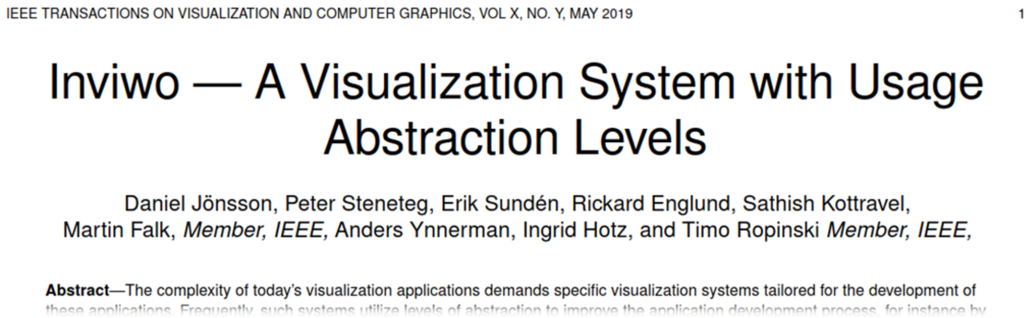


IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS, VOL X, NO. Y, MAY 2019 1

Inviwo — A Visualization System with Usage Abstraction Levels

Daniel Jönsson, Peter Steneteg, Erik Sundén, Rickard Englund, Sathish Kottravel,
Martin Falk, *Member, IEEE,* Anders Ynnerman, Ingrid Hotz, and Timo Ropinski *Member, IEEE,*

Abstract—The complexity of today's visualization applications demands specific visualization systems tailored for the development of these applications. Frequently, such systems utilize levels of abstraction to improve the application development process, for instance by

D. Jönsson, *et al.*, "Inviwo – A Visualization System with Usage Abstraction Levels" in *IEEE Transactions on Visualization & Computer Graphics*, 2019.
doi: 10.1109/TVCG.2019.2920639

Possibilities

High-level abstractions

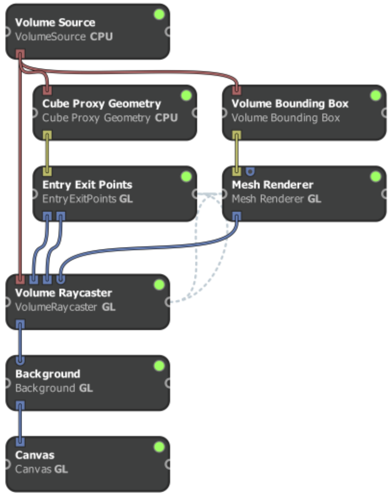
- Visualization pipeline creation/editing

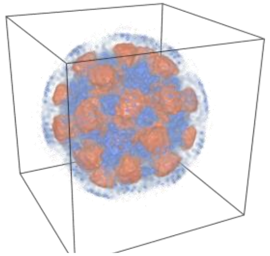
Mid-level abstractions

- Python
- Web (HTML, JavaScript, ...)

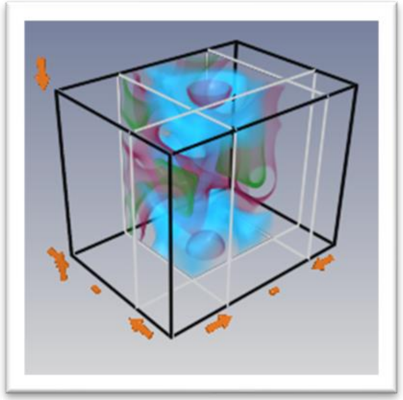
Low-level abstractions

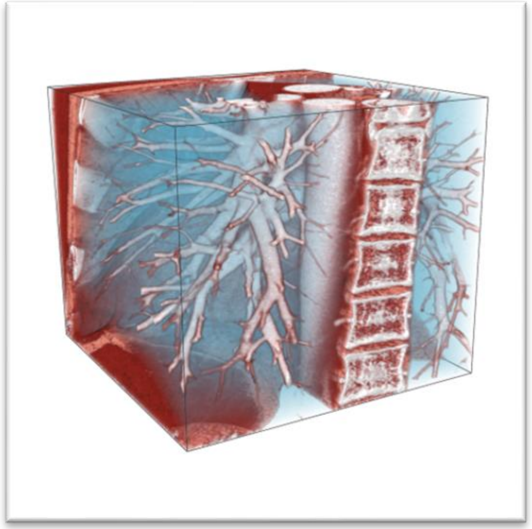
- Data handling
- C++

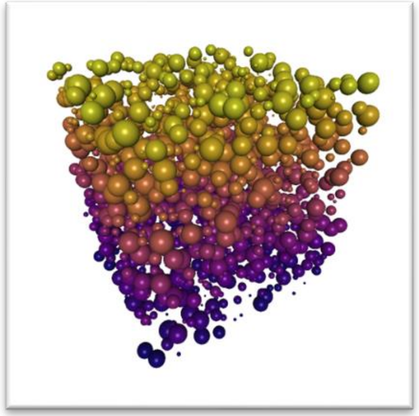




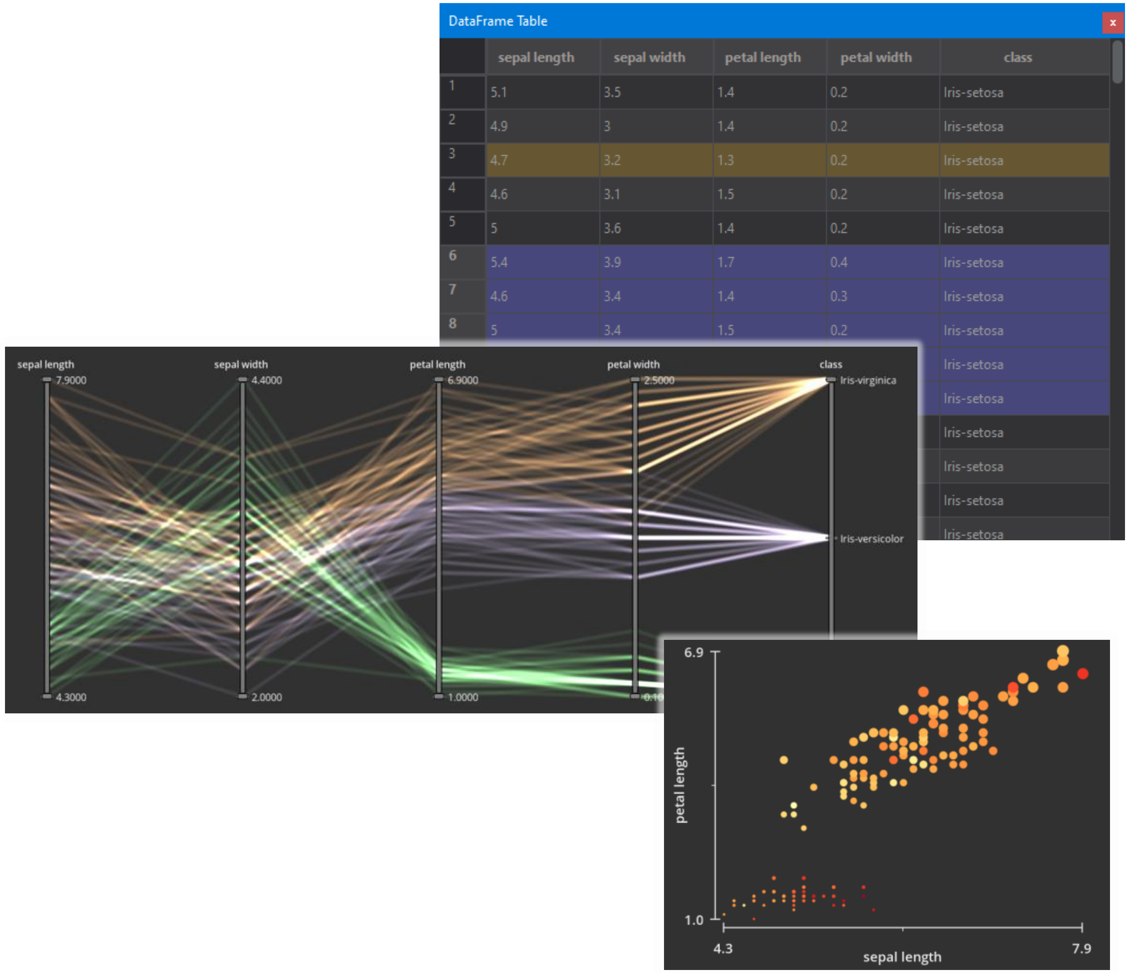
Feline calicivirus







Tabular Data, Volumes, Geometry, ...



DataFrame Table

	sepal length	sepal width	petal length	petal width	class
1	5.1	3.5	1.4	0.2	Iris-setosa
2	4.9	3	1.4	0.2	Iris-setosa
3	4.7	3.2	1.3	0.2	Iris-setosa
4	4.6	3.1	1.5	0.2	Iris-setosa
5	5	3.6	1.4	0.2	Iris-setosa
6	5.4	3.9	1.7	0.4	Iris-setosa
7	4.6	3.4	1.4	0.3	Iris-setosa
8	5	3.4	1.5	0.2	Iris-setosa
					Iris-setosa
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					Iris-setosa
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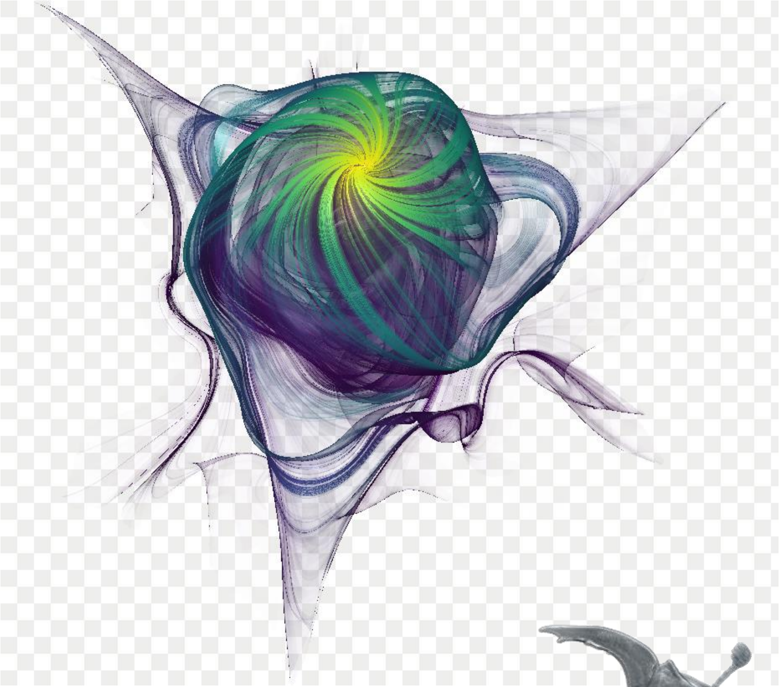
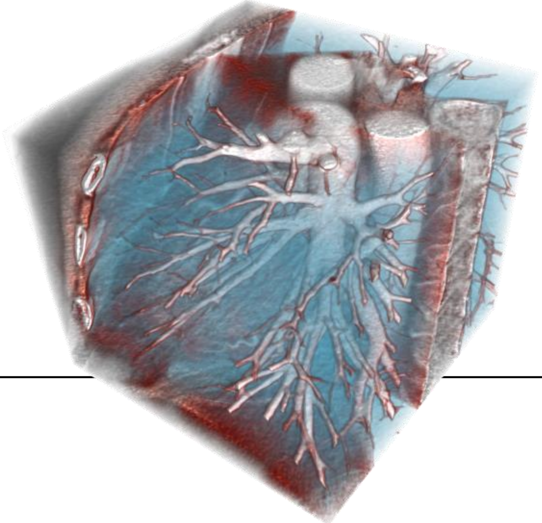
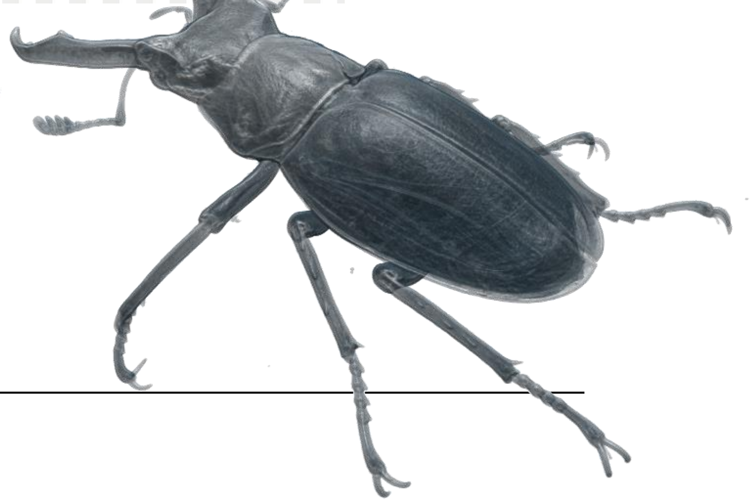
					Iris-setosa







Application showcases

– what’s possible –

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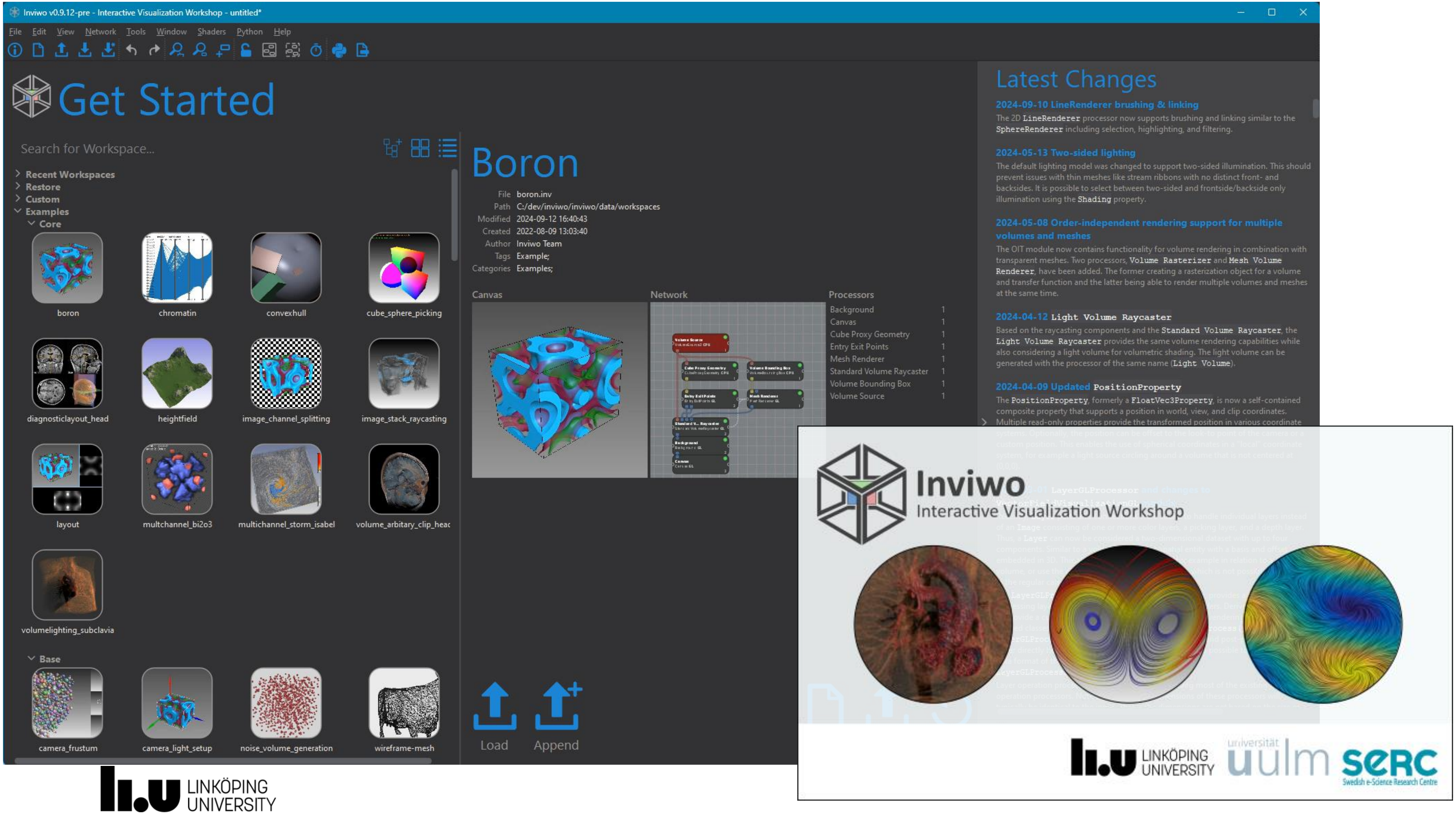

File boron.inv
Path C:/dev/inviwo/inviwo/data/workspaces
Modified 2024-09-12 16:40:43
Created 2022-08-09 13:03:40
Author Inviwo Team
Tags Example;
Categories Examples;

Processors	
Background	1
Canvas	1
Cube Proxy Geometry	1
Entry Exit Points	1
Mesh Renderer	1
Standard Volume Raycaster	1
Volume Bounding Box	1
Volume Source	1

Latest Changes

2024-09-10 LineRenderer brushing & linking

The 2D `LineRenderer` processor now supports brushing and linking similar to the `SphereRenderer` including selection, highlighting, and filtering.

2024-05-13 Two-sided lighting

The default lighting model was changed to support two-sided illumination. This should prevent issues with thin meshes like stream ribbons with no distinct front- and backsides. It is possible to select between two-sided and frontside/backside only illumination using the `Shading` property.

2024-05-08 Order-independent rendering support for multiple volumes and meshes

The OIT module now contains functionality for volume rendering in combination with transparent meshes. Two processors, `Volume Rasterizer` and `Mesh Volume Renderer`, have been added. The former creating a rasterization object for a volume and transfer function and the latter being able to render multiple volumes and meshes at the same time.

2024-04-12 `Light Volume Raycaster`

Based on the raycasting components and the `Standard Volume Raycaster`, the `Light Volume Raycaster` provides the same volume rendering capabilities while also considering a light volume for volumetric shading. The light volume can be generated with the processor of the same name (`Light Volume`).

2024-04-09 Updated `PositionProperty`

The `PositionProperty`, formerly a `FloatVec3Property`, is now a self-contained composite property that supports a position in world, view, and clip coordinates. Multiple read-only properties provide the transformed position in various coordinate systems. Optionally, the position can be offset to the look-to point of the camera or a custom position. This enables the use of spherical coordinates in a "local" coordinate system, for example a light source circling around a volume that is not centered at (0,0,0).

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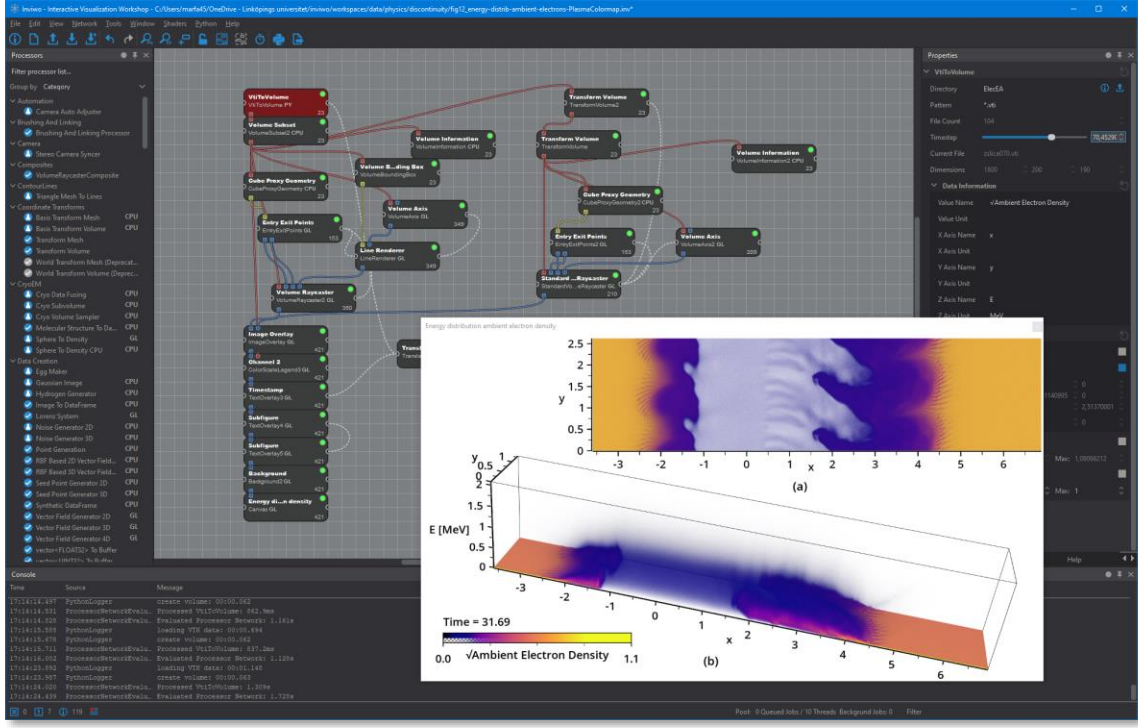
Physics: interstellar jets

Mass ejection from black holes

- Simulation of plasma physics

Data courtesy of Mark Dieckmann, LiU



Inviwo - Interactive Visualization Workshop - C:/Users/marfa45/OneDrive - Linköpings universitet/inviwo/workspaces/data/physics/discontinuity/fig12_energy-distrib-ambient-electrons-PlasmaColormap.inv*
File
Edit
View
Network
Tools
Window
Shaders
Python
Help
Processors
Filter processor list...
Properties
Console
Energy distribution ambient electron density
2.5
2
1.5
y
1
0.5
0
-3
-2
-1
0
1
x
2
3
4
5
6
(a)
E [MeV]
Time = 31.69
0.0
√Ambient Electron Density
1.1
(b)

VtiToVolume

Directory	ElecEA
Pattern	*.vti
File Count	104
Timestep	70,4529€
Current File	zslice070.vti
Dimensions	1800 200 190

Data Information

Value Name	√Ambient Electron Density
Value Unit	
X Axis Name	x
X Axis Unit	
Y Axis Name	y
Y Axis Unit	
Z Axis Name	E
Z Axis Unit	MeV

```
Time          Source                   Message
17:14:14.497  PythonLogger             create volume: 00:00.062
17:14:14.531  ProcessorNetworkEvalu..  Processed VtiToVolume: 862.9ms
17:14:14.828  ProcessorNetworkEvalu..  Evaluated Processor Network: 1.161s
17:14:15.588  PythonLogger             loading VTK data: 00:00.694
17:14:15.678  PythonLogger             create volume: 00:00.062
17:14:15.711  ProcessorNetworkEvalu..  Processed VtiToVolume: 837.2ms
17:14:16.002  ProcessorNetworkEvalu..  Evaluated Processor Network: 1.128s
17:14:23.892  PythonLogger             loading VTK data: 00:01.148
17:14:23.987  PythonLogger             create volume: 00:00.063
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17:14:24.439  ProcessorNetworkEvalu..  Evaluated Processor Network: 1.729s
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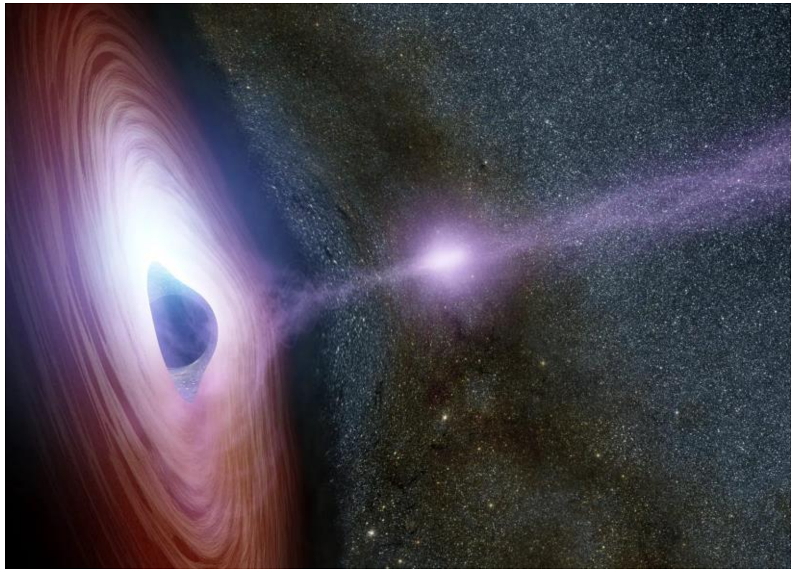
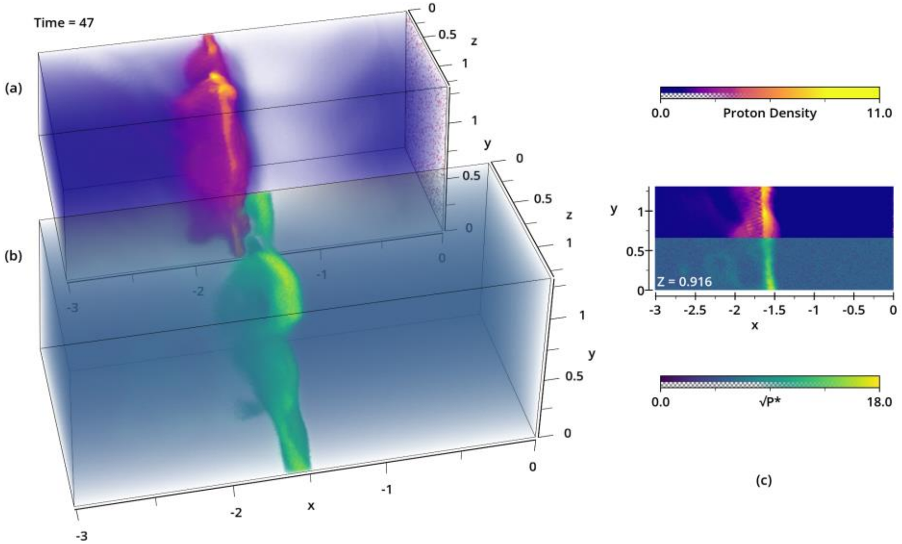
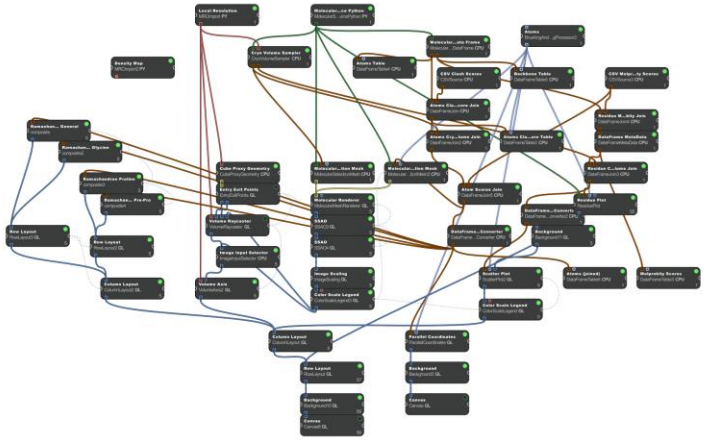


Artist’s concept of black hole [NASA/JPL-Caltech]



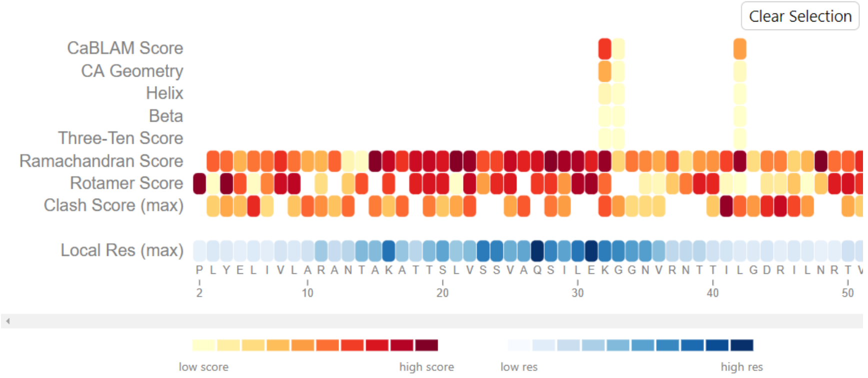
Cyro-EM model evaluation & validation

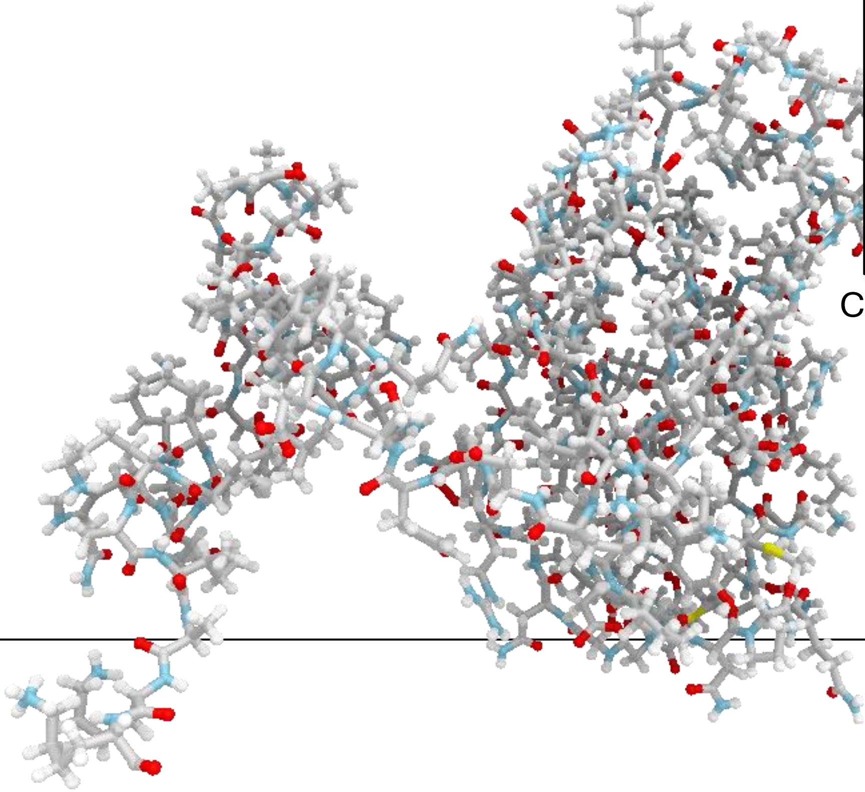


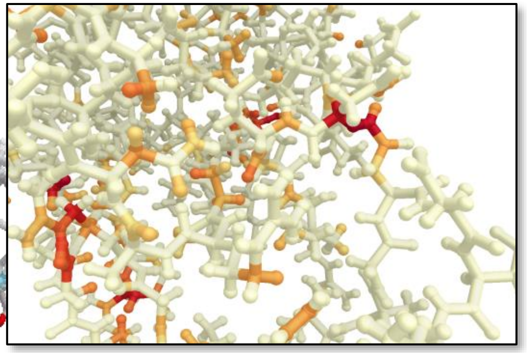
Atomic models based on data from cryo electron microscopy

Requires validation based on different metrics

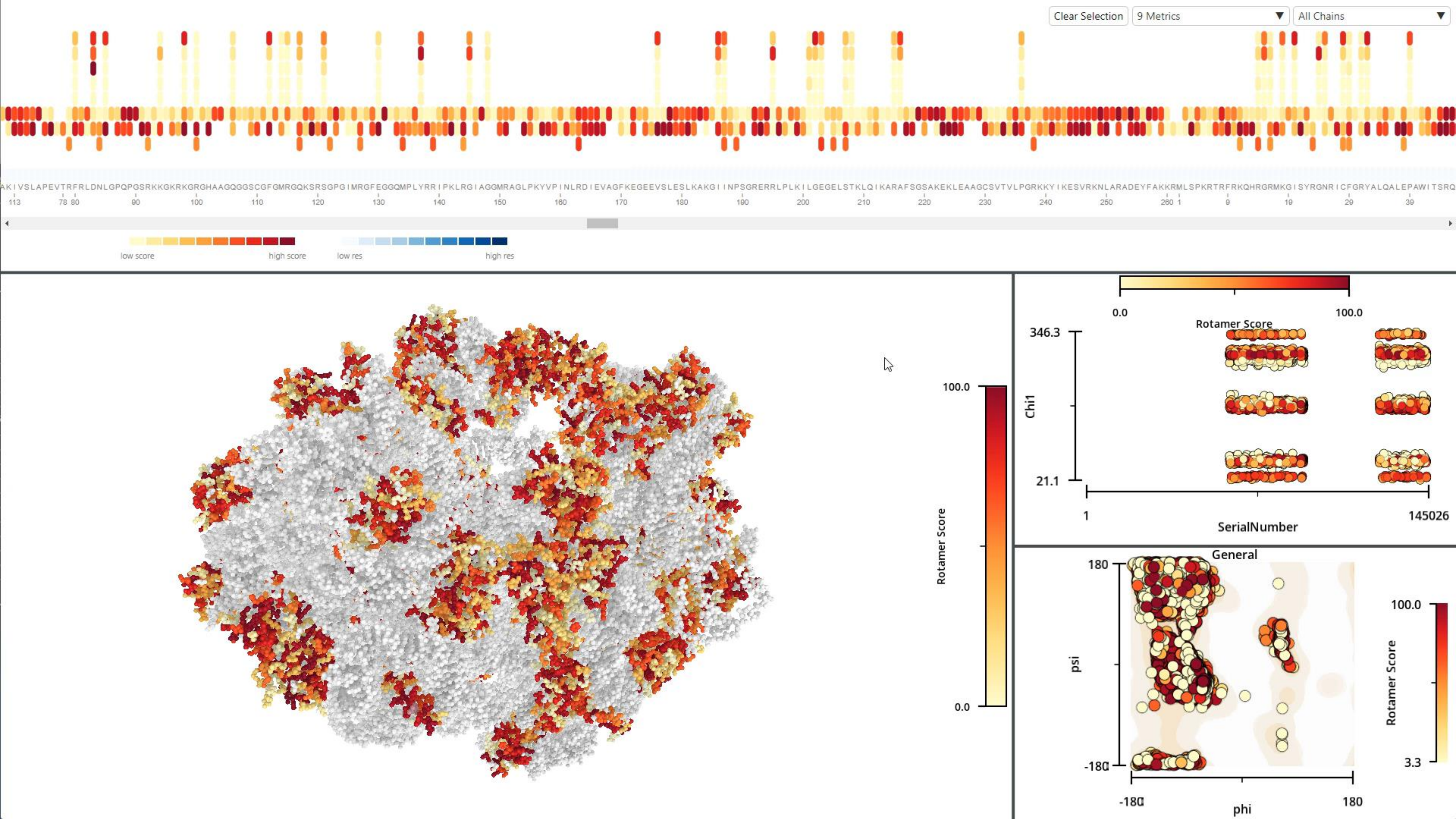
Explore metrics in the spatial context of the structure







Color-mapped validation metric


Clear Selection
9 Metrics
All Chains
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113 78 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 1 9 19 29 39
low score
high score
low res
high res
100.0
Rotamer Score
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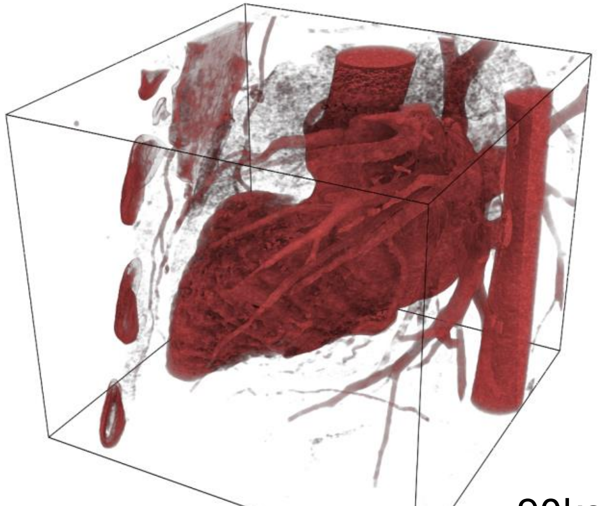
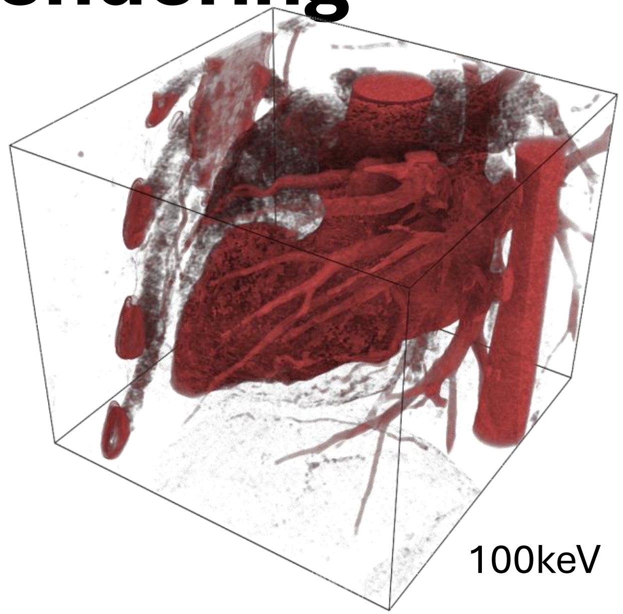
0.0
100.0
Rotamer Score
346.3
Chi1
21.1
1
SerialNumber
145026
General
180
psi
-180
-180
phi
180
100.0
Rotamer Score
3.3

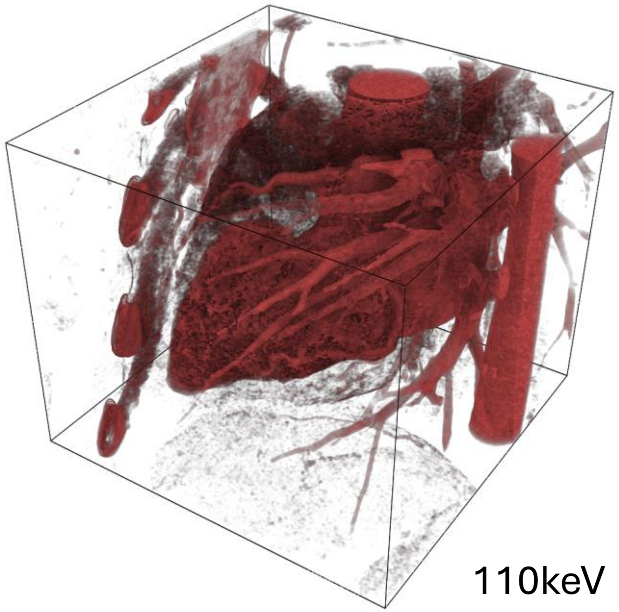
Multi-spectral volume rendering



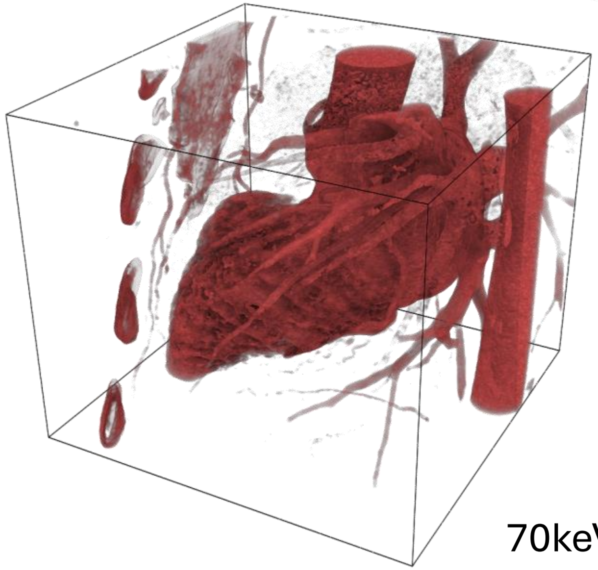
90keV



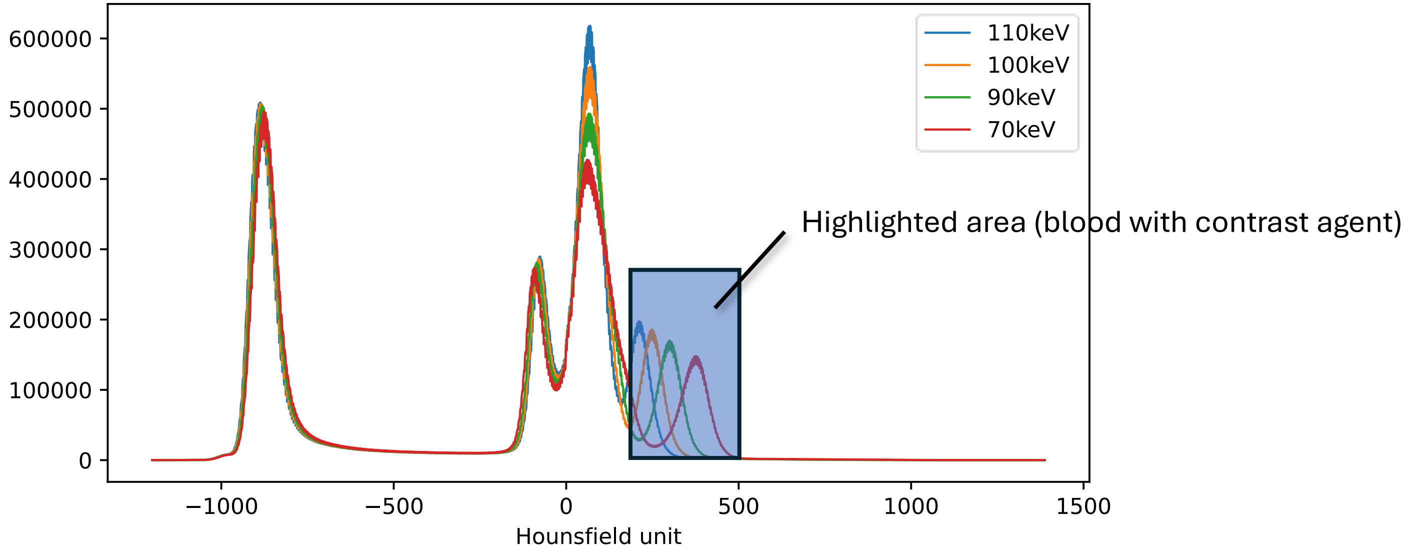
100keV



110keV



70keV



Highlighted area (blood with contrast agent)

Inviwo.org

inviwo.slack.com

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D. Jönsson, *et al*., “Inviwo - A Visualization System with Usage Abstraction Levels” in *IEEE Transactions on Visualization & Computer Graphics*, 2019.
doi: 10.1109/TVCG.2019.2920639