

SlicerAstro: a 3-D interactive visual analytics tool for HI data

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Future HI blind survey

APERTIF (Verheijen et al., 2009, in *Panoramic Radio Astronomy, PoS*) will observe HI in hundreds of thousands of galaxies.

Data rate 10 cubes/week. We will enter in the *Big data* domain for two reasons:

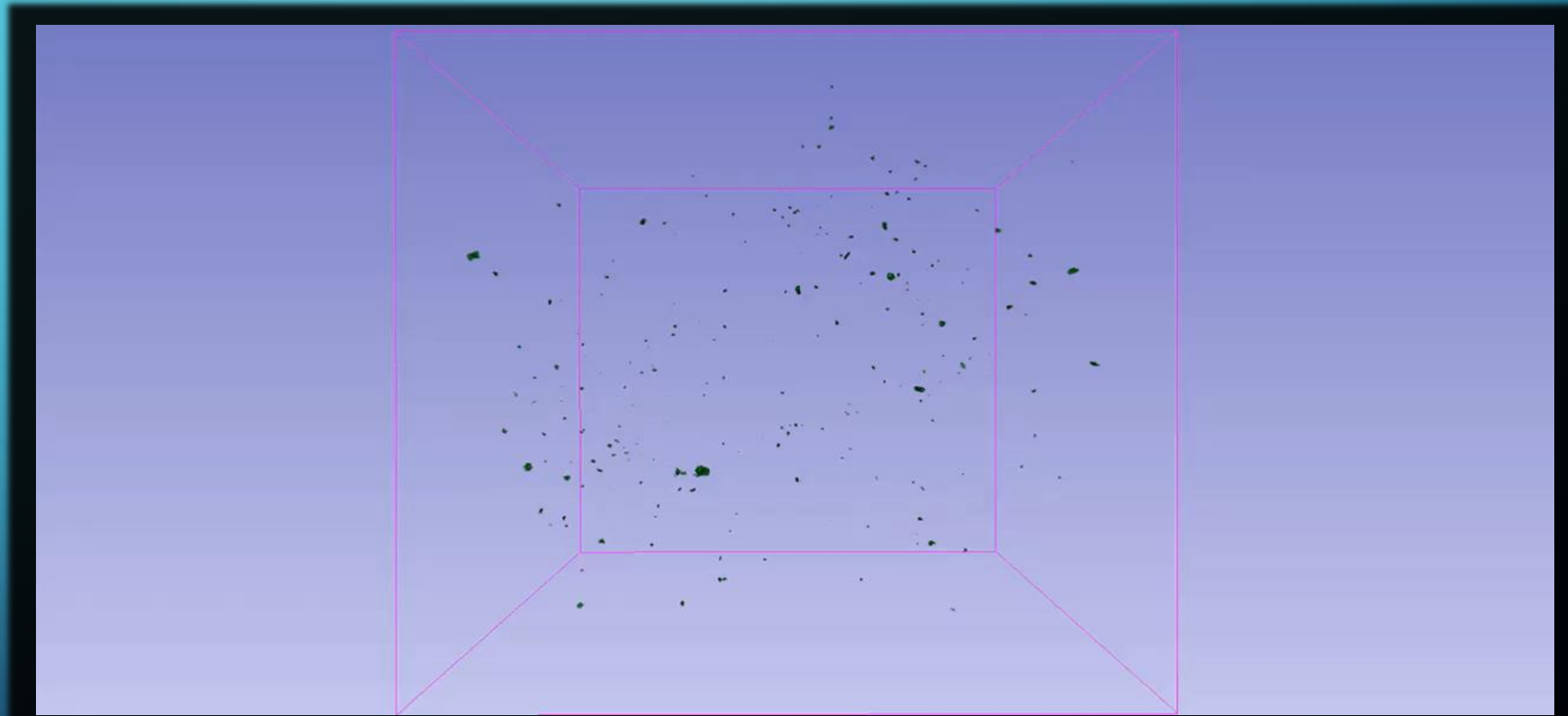


1 An APERTIF data cube :
 $\sim 10^{11}$ voxels.

most (99%) will be dominated by noise

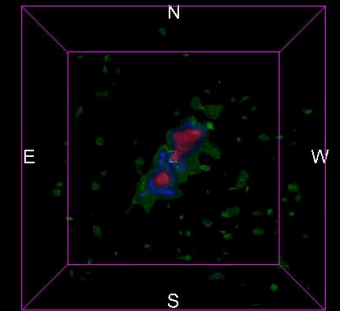
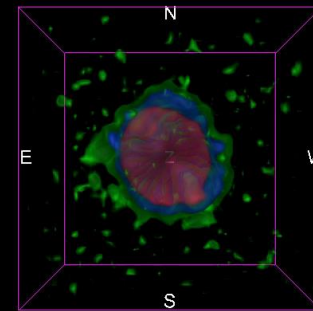
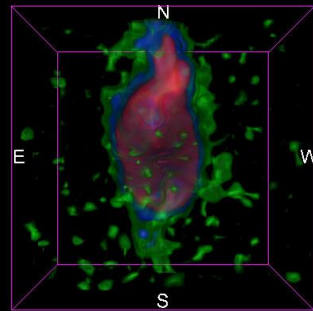
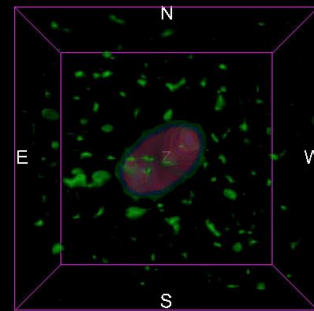
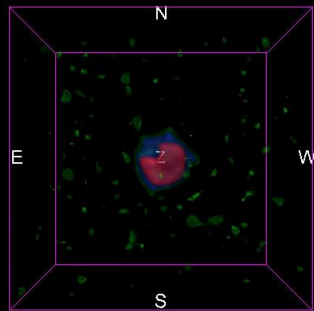
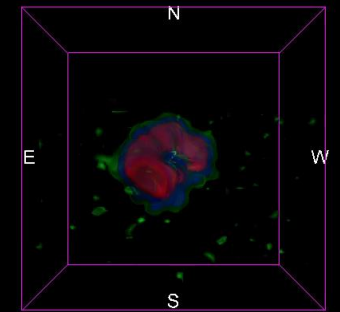
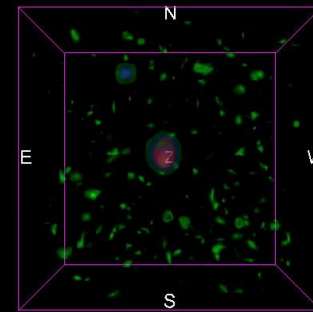
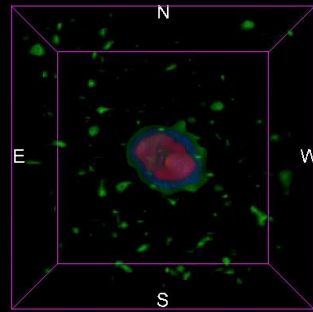
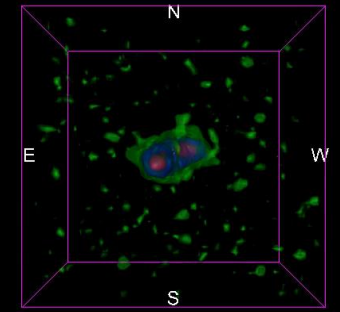
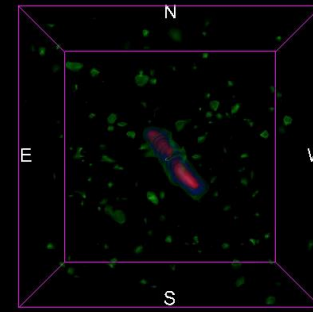
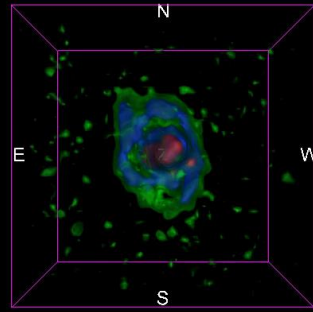
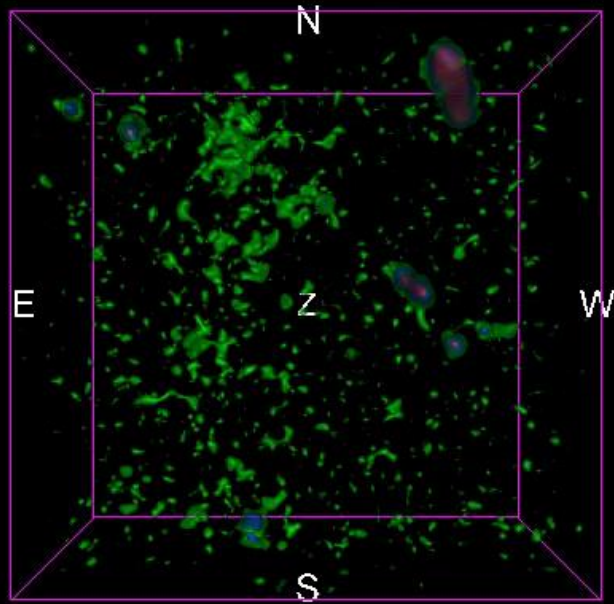
2 Each data cube contains ~ 100 HI sources

Subcubes around sources will typically contain $\sim 10^5$ voxels;



Data from Ramatsoku et al., 2016.

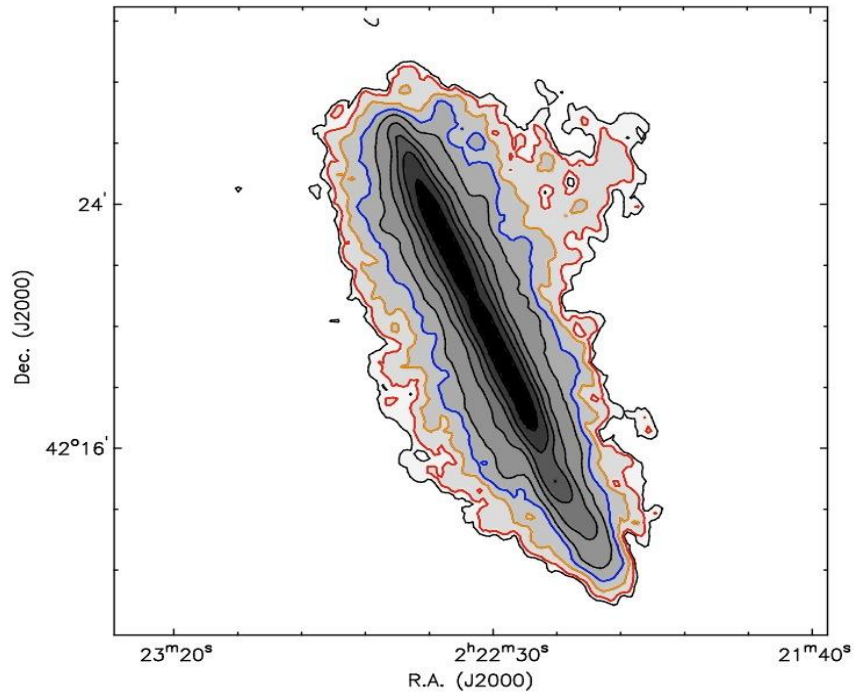
Galaxies in the Ursa Major cluster (courtesy Busekool and Verheijen)



Signatures of gas accretion and removal

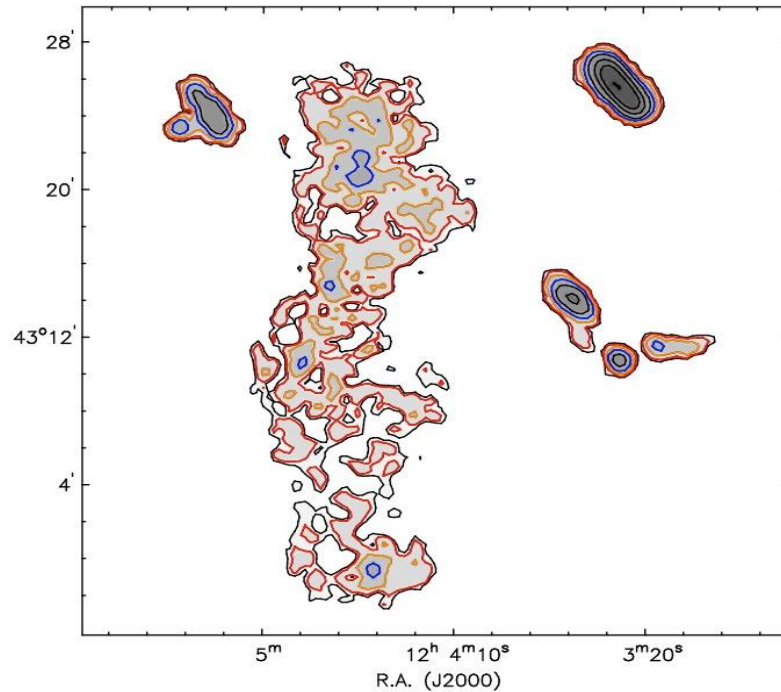
extraplanar gas

NGC 891



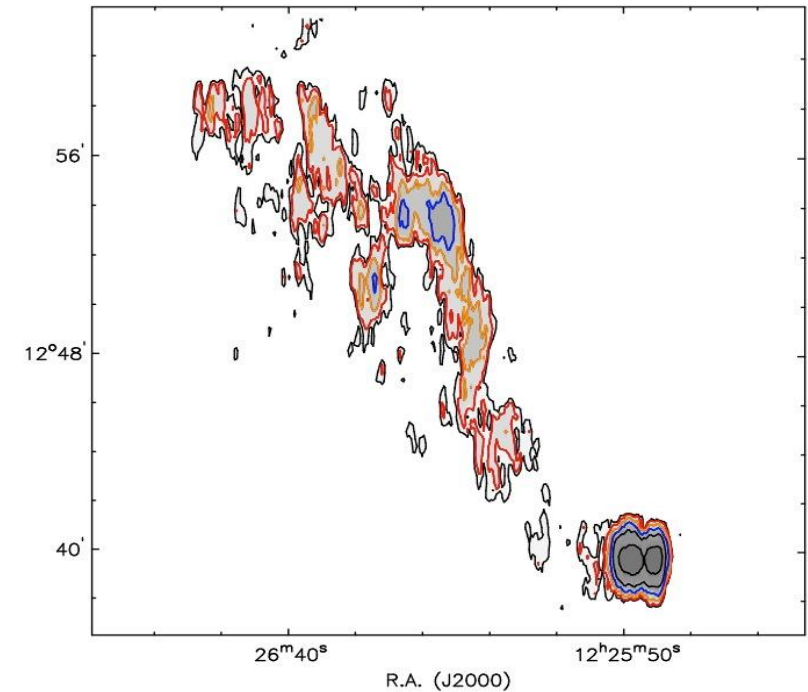
tidal filaments

NGC 4111



ram-pressure tails

NGC 4388



Images credits to M. Verheijen

Common to these tell-tale signatures:

- low column density
- unusual kinematics

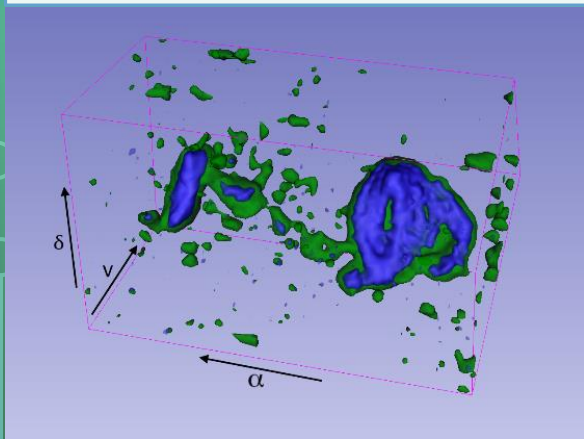
*good visualization techniques
can help finding such features*

SlicerAstro: Aim of the project

SlicerAstro: an **interactive 3D** visual analytics toolset to boost the inspection and analysis of 3-D astronomical data for 3D Slicer

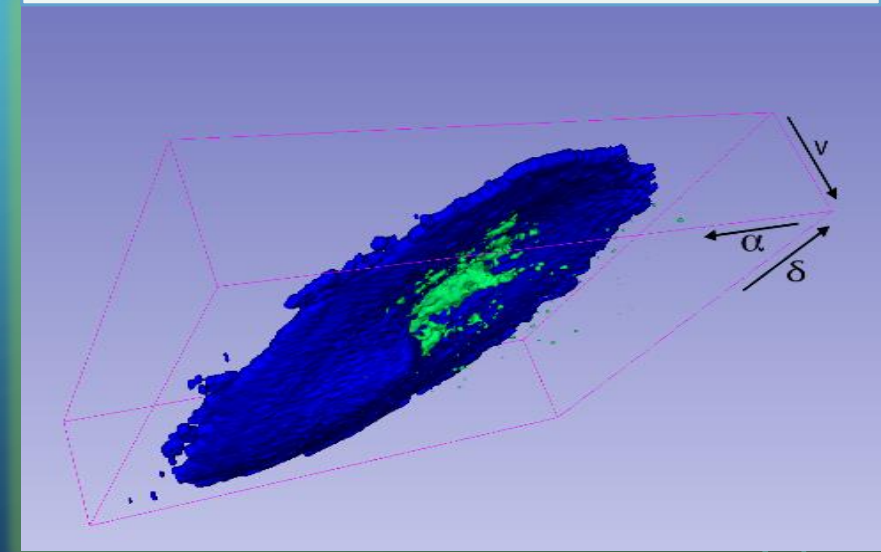
handling FITS and WCS coordinates

Interactive smoothing

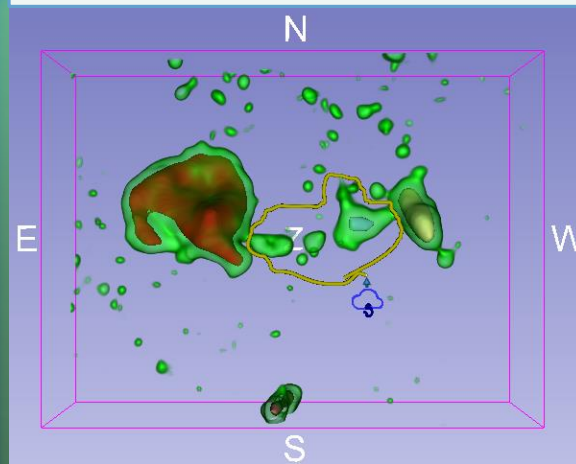


SlicerAstro

Comparative visualization of data and kinematic models

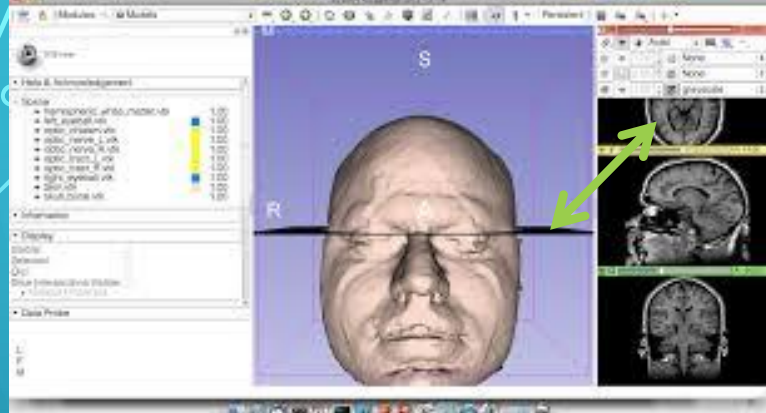


3-D selection



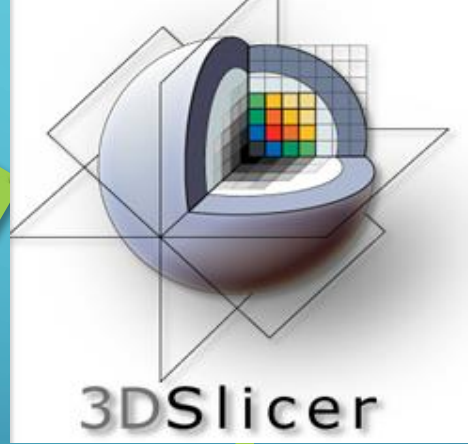
Why 3DSlicer?

Synergies between astronomical and medical visualization



Open Source

www.slicer.org



Long-term maintainability



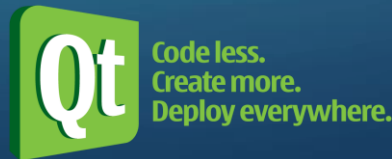
High level of modularity



CPU/GPU Volume Rendering (VTK>7.1)



Multi-platform (Qt>4.8.7)



Well documented:

- SlicerWiki
- github.com/Slicer/Slicer
- Mantis bug report

See also Punzo et al., 2015, *Astronomy and Computing*, 12, 86.

Downloading SlicerAstro

The screenshot displays the SlicerAstro software interface. The main window shows the SlicerAstro logo and navigation buttons: Load Data, Download Sample Data, Tutorials, and Customize Slicer. A red circle highlights the 'Extensions Manager' icon in the top toolbar. An 'Extensions Manager' window is open, showing a list of Slicer Extensions. The 'Astronomy (1)' category is selected, and the 'SlicerAstro' extension by Davide Punzo (Kapteyn Institute) is highlighted. The extension details show a star rating of 0 and an 'UNINSTALL' button. The background shows a 3D visualization of a brain slice with a pink bounding box and a north arrow 'N'. The bottom right corner of the main window shows a timer at 4h 51m 30.667s.

File Edit View Help

Modules: Welcome to SlicerAstro

Files

3DSlicer

Slicer Astro

Load Data Download Sample Data

Tutorials Customize Slicer

Feedback

Share your stories with us and let us know about how SlicerAstro has enabled your research.

We are always interested in improving SlicerAstro, and every submission will be carefully read.

About Overview Acknowledgment

Data Probe

Show Zoomed Slice

L
F
B

Extensions Manager

Manage Extensions (1) Install Extensions Search...

Slicer Extensions

Categories

- All
- Applications (1)
- Astronomy (1)**
- Cardiac (2)
- Chest Imaging Platform (1)
- Converters (1)
- DICOM (1)
- Developer Tools (3)
- Diffusion (2)
 - Tractography (1)
- Editor Effects (1)
- Examples (1)
- Exporter (1)
- Filtering (2)
- IGT (9)
- Informatics (4)
- Libraries (1)
- Mesh Generation (1)
- Nuclear Medicine (1)

Slicer Astro

SlicerAstro
Davide Punzo (Kapteyn Institute)

UNINSTALL

Restart Close

4h 51m 30.667s

SlicerAstro: inspecting HI in a galaxy

File Edit View Help

Modules: Astro Volume

3DSlicer

Help & Acknowledgement

Active Volume temp

Volume Information

Display

Lookup Table: Grey

Interpolate:

W: 0.0103 Auto W/L L: 0.0034

Threshold: Off

-0.0027 0.0096

Rendering

Activate:

2-D/3-D synchroniz: Synchroniz

Preset: ThreeSurfaces

Shift: Enable Display ROI

Rendering: VTK GPU Ray Casting

Quality: Maximum Quality

Mask Visualization

Create surface Edit segmentation

No node is selected

Color Opacity Name

Data Probe

Show Zoomed Slice

L
F
B

A tidal tail

The regularly rotating disk

N

E

W

C

3D pros:

Overview of coherent structures in space **and** velocity

R

Y

G

See also Punzo et al., 2015, *Astronomy and Computing*, 12, 86.

Data by M. Ramatsoku

SlicerAstro: inspecting HI in a galaxy

3-D disadvantages

Input issues:
mouse interactions

Output issues:
projection effects

File Edit View Help
Modules: Astro Volume

3DSlicer

Help & Acknowledgement

Active Volume: WEIN069

Volume Information

Display

Lookup Table: Grey

Interpolate:

W: 0.0140 Auto W/L L: 0.0049

Threshold: Off

Rendering

Activate:

2-D/3-D synch: Synchronize

Preset: ThreeSurfaces

Shift: Enable Display ROI Fit to Volume

Rendering: VTK GPU Ray Casting

Quality: Maximum Quality

Mask Visualization

Create surface Edit segmentation

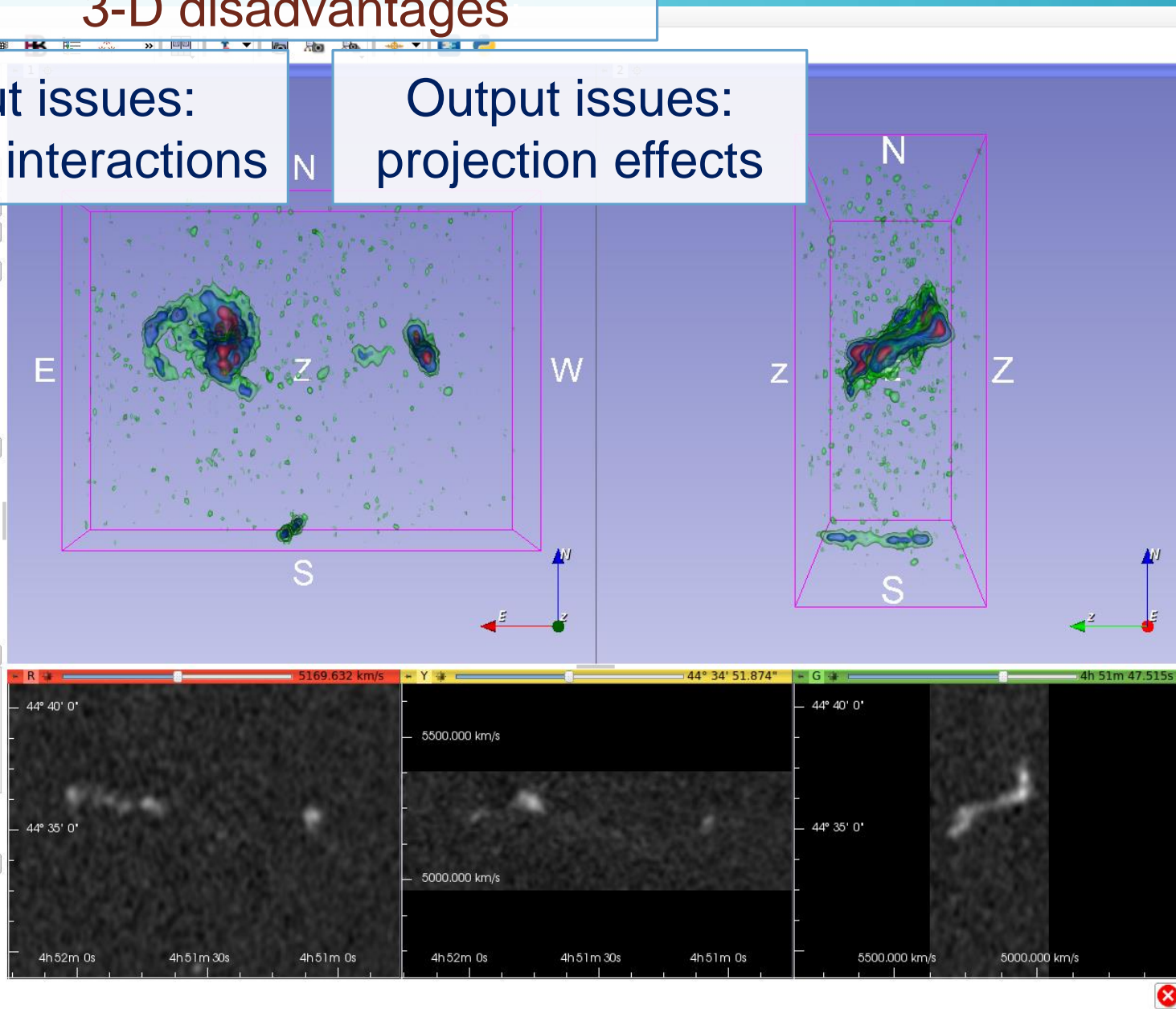
No node is selected

Color	Opacity	Name

Data Probe

Red WCS: 4h 51m 50.160s, 44° 35' 45.233", 5169.632 km/s (VOPT-F2W) XY

L None None
F None None
B WEIN069 (45, 69, 24) 2.229663 mJy/beam

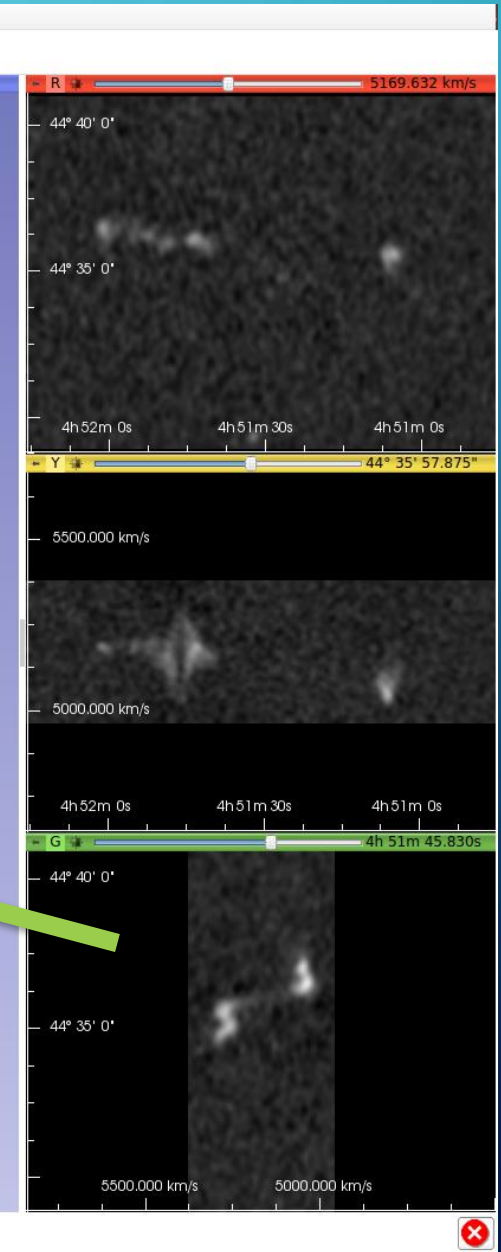
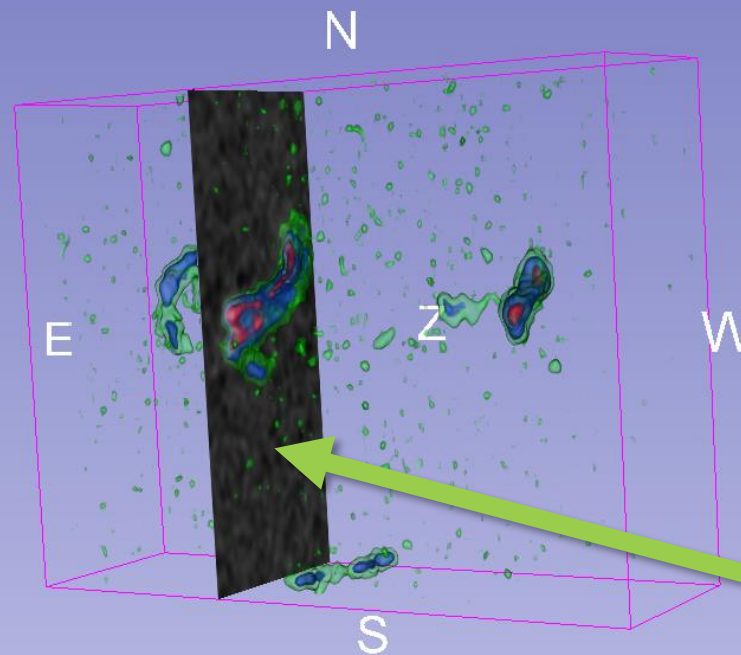


SlicerAstro: inspecting HI in a galaxy

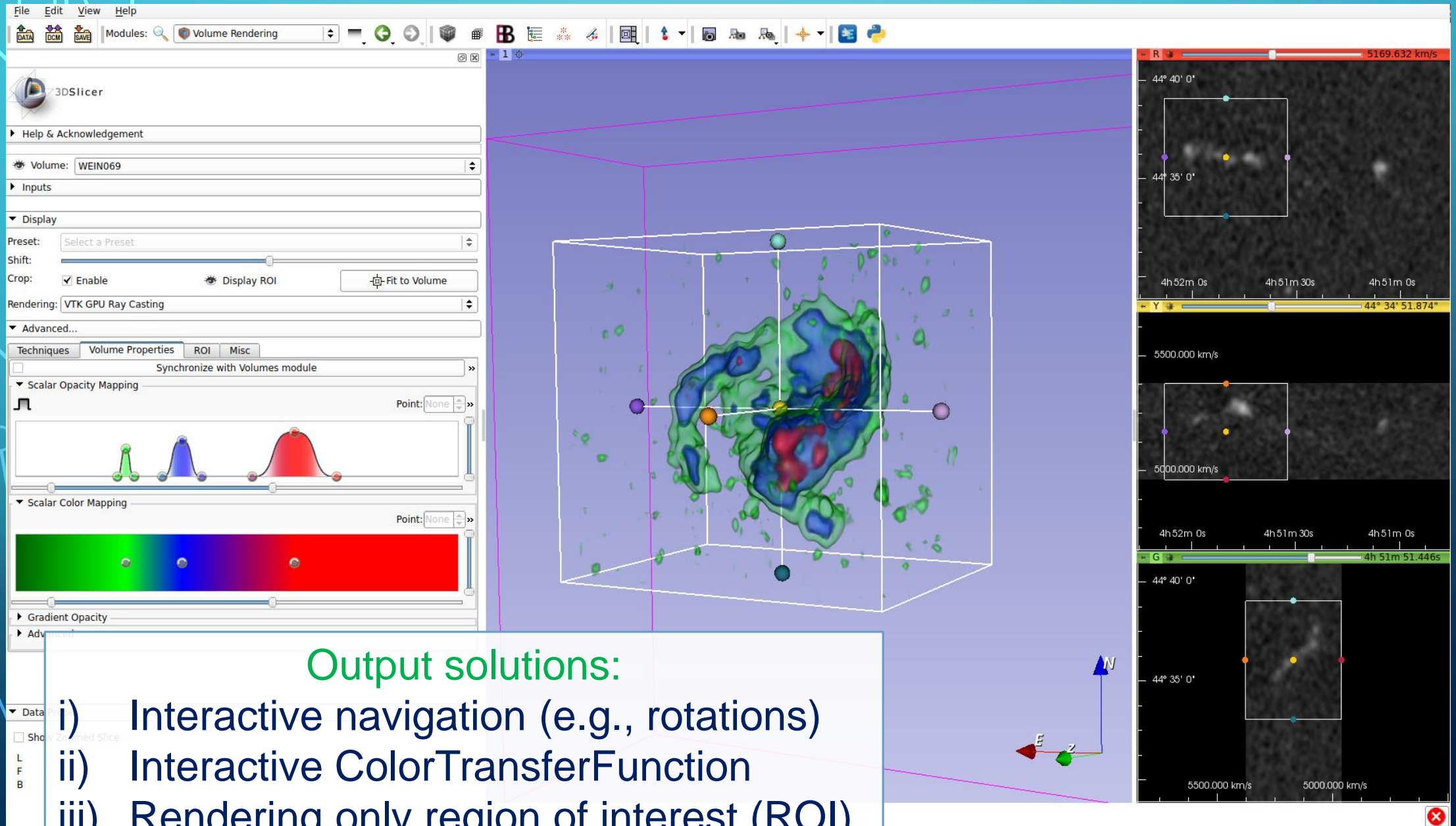
The screenshot shows the SlicerAstro software interface. The top menu bar includes File, Edit, View, and Help. Below the menu is a toolbar with icons for DATA, DCM, SAVE, and other functions. The main window displays the 3DSlicer logo and a sidebar with various panels. The 'Active Volume' is set to WEIN069. The 'Display' panel shows 'Lookup Table: Grey', 'Interpolate: [checked]', 'W: 0.0140', 'Auto W/L', 'L: 0.0049', and 'Threshold: Off'. The 'Rendering' panel shows 'Activate: [checked]', '2-D/3-D synch: Synchronize', 'Preset: ThreeSurfaces', 'Shift: [checked]', 'Crop: [unchecked] Enable [checked] Display ROI [checked] Fit to Volume [checked]', 'Rendering: VTK GPU Ray Casting', and 'Quality: Maximum Quality'. The 'Mask Visualization' panel shows 'No node is selected' and a table with columns for Color, Opacity, and Name. The 'Data Probe' panel shows 'Green WCS: 4h 51m 45.758s, 44° 36' 27.295", 5032.605 km/s (VOPT-F2W) ZY' and 'L None None', 'F None None', 'B WEIN069 (53, 76, 8) 10.037752 mJy/beam'.

Input solutions:

- i) 2-D/3-D link
- ii) CloudLasso selection (see next slides)



SlicerAstro: inspecting HI in a galaxy



Output solutions:

- i) Interactive navigation (e.g., rotations)
- ii) Interactive ColorTransferFunction
- iii) Rendering only region of interest (ROI)

SlicerAstro: inspecting a faint HI filament

CPU (OpenMP) /
GPU(OpenGL)
filtering techniques:

A

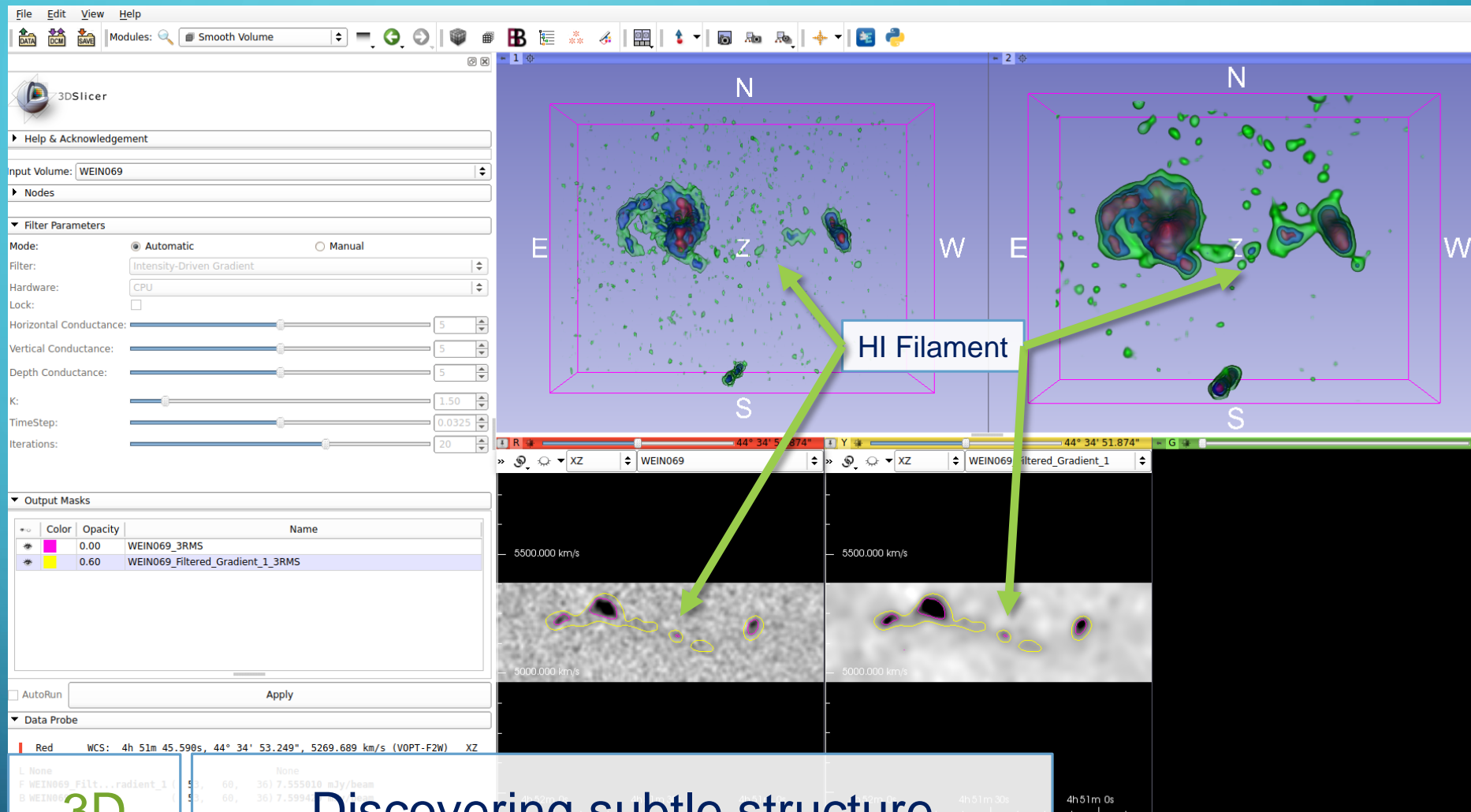
Box

B

Gaussian

C

Intensity-
driven
gradient



See also Punzo et al., 2016, *Astronomy and Computing*, 17, 163.

3-D selection in SlicerAstro

The screenshot displays the SlicerAstro software interface. The top menu bar includes File, Edit, View, and Help. Below it is a toolbar with various icons. The main window shows two 3D views of a segmented volume, with a red circle highlighting the CloudLasso tool in the Effects panel. The left sidebar contains the Segmentation panel, which shows the current segmentation and a list of segments. The bottom status bar displays coordinates and other data.

File Edit View Help
Modules: Segment Editor

3DSlicer

Help & Acknowledgement

Segmentation: Segmentation
Master volume: WEIN069_Filtered_Gradient_1

+ Add segment - Remove selected Create surface

Color	Name
	WEIN069_3RMS
	WEIN069_Filtered_Gradient_1_3RMS
	Segment_3

Effects

AstroCloudLasso
Left-click and drag in a slice or 3D view to use respectively a 2-D or 3-D cloud lasso selection tool. The initial lower threshold value is 3 RMS.

Threshold range values:
0.000486 0.011831

Automatic Threshold Updating Mode
 Erase Mode

Masking

Editable area: Everywhere

Editable intensity range:

0.00

Overwrite other segments: All segments

CloudLasso can be used for:

Selecting regions of interest for further analysis

Modify interactively masks

3-D comparative visualization of models in SlicerAstro

3DSlicer

▶ Help & Acknowledgement

Input Volume: WEIN069

▶ Nodes

▶ Input Mask

▶ Model Fitting Parameters

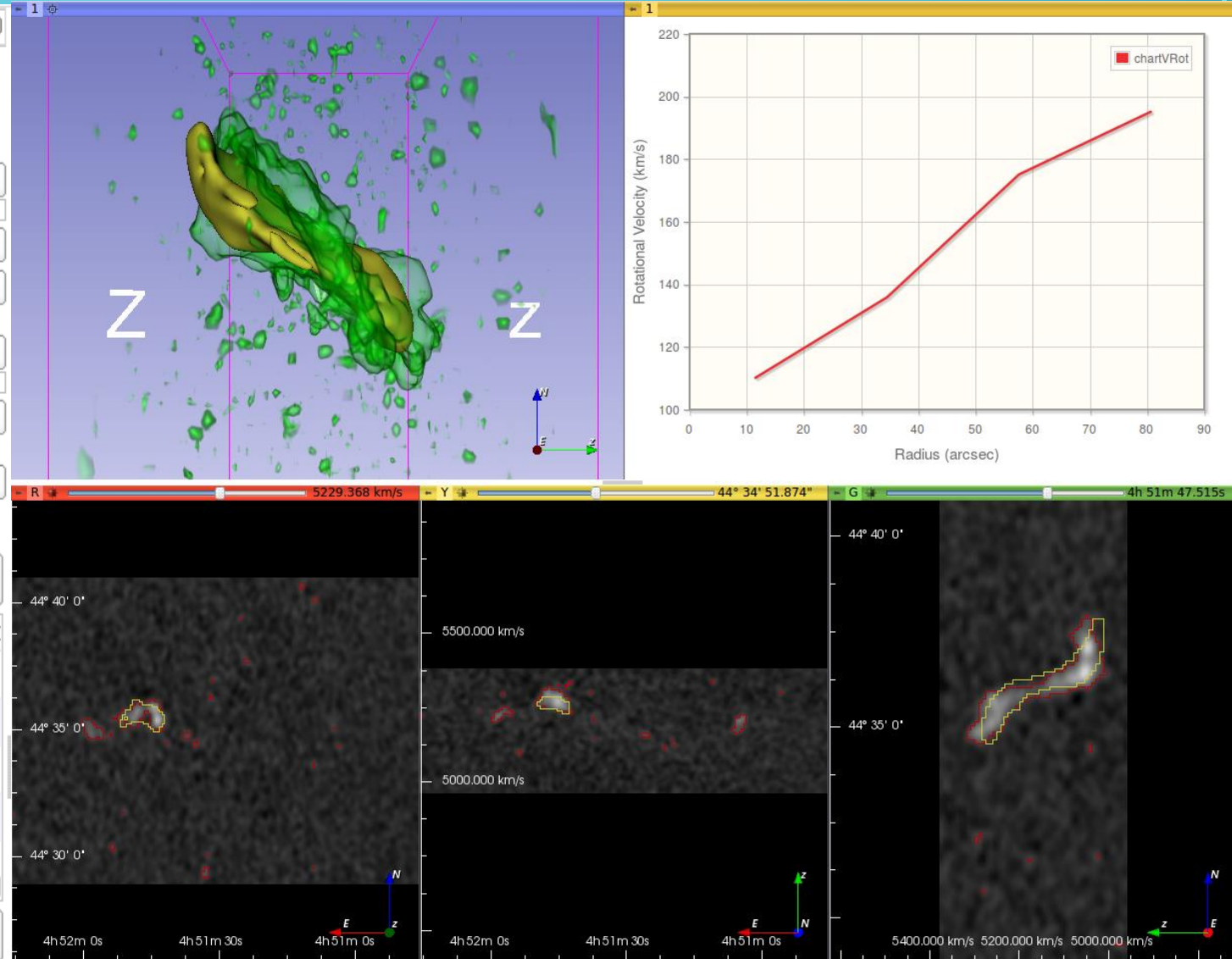
▼ Output

Contour level: 3.00 RMS

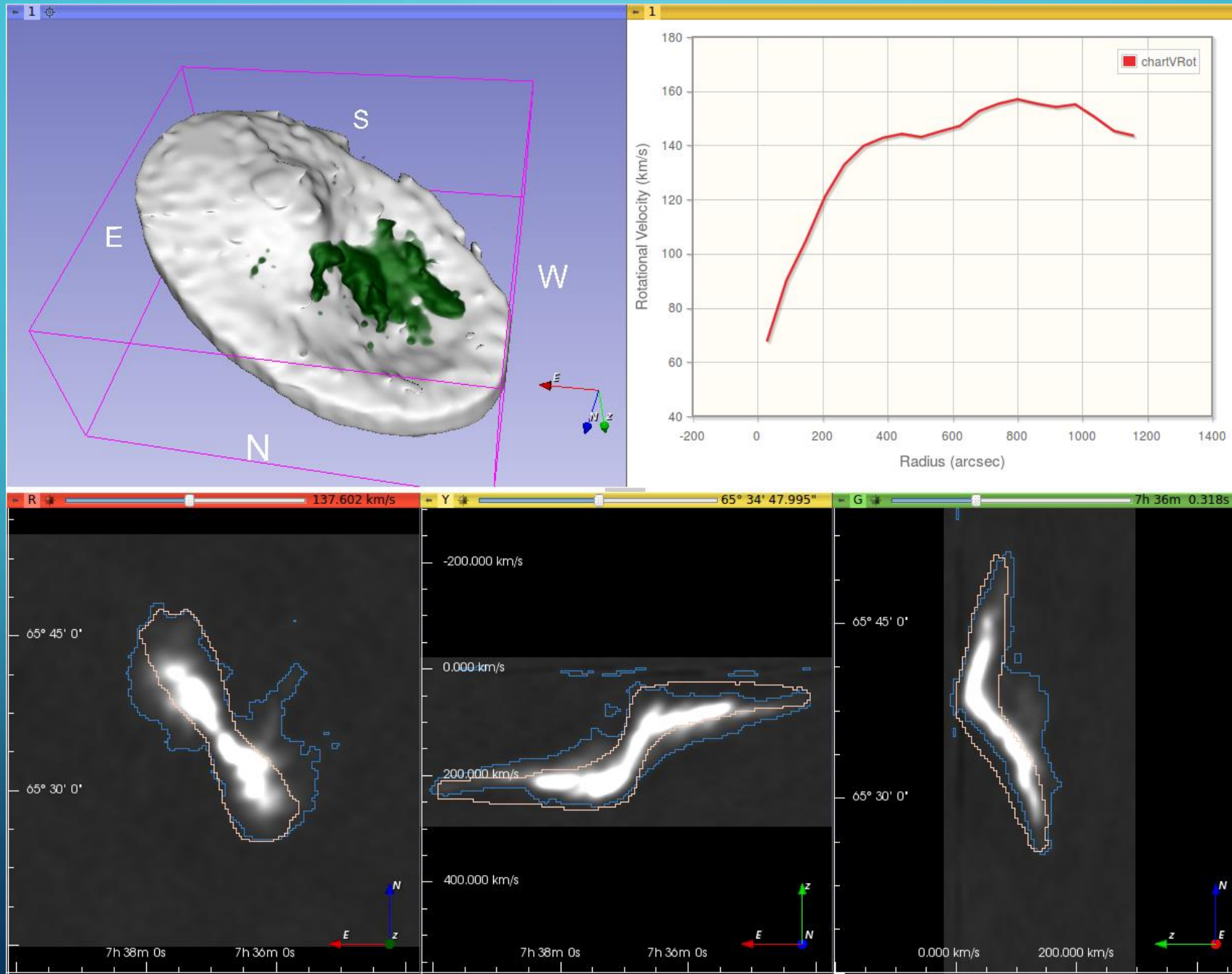
Visualize Model

	Radius (arcsec)	VRot (km/s)	Inc (degree)	Phi (degree)	VSys (km/s)	VDisp (km/s)	C
1	11.52	110.159	40.3133	191.993	5086.73	8.54883	1
2	34.56	135.901	41.8284	186.599	5086.73	17.5959	1
3	57.6	175.081	40.7324	188.395	5086.73	6.69922	1
4	80.64	195.106	39.095	188.75	5086.73	6.45571	1

Calculate and Visualize Model



3-D comparative visualization of models in SlicerAstro



Ongoing work

SlicerAstro is under development:

our TO DO list

1. Live 1-D profiles;
2. Histograms and statistics;
3. Moments maps;
4. P-V diagrams;
5. Data-cube cropping;
6. Overlay data-cube with different WCS and gridding;
7. Virtual Observatory connection.

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AGILE approach:

Development cycle
driven
by the users!!!

Better interface
friendliness

Bug corrections

Additional Features
(e.g, analysis)

Final Remarks

A

The main aim of SlicerAstro is to aid source inspection and interactive analysis of spectral line data;

B

The 3-D visualization gives an immediate overview of coherent structures in space **and** velocity;

C

The 3-D visualization (coupled with filtering and modeling) greatly helps the discovery of faint structures;

D

SlicerAstro source code available at:

<https://github.com/Punzo/SlicerAstro>

Binaries (Linux and Mac) available in the 3DSlicer Extension Manager

<http://download.slicer.org/>

We thank S. Pieper (Isomics), A. Lasso (Queen's University) and K. Martin (Kitware) for their feedback and help.