methods of computational science

visualization

day ii - bottlenecks/parallel-viz

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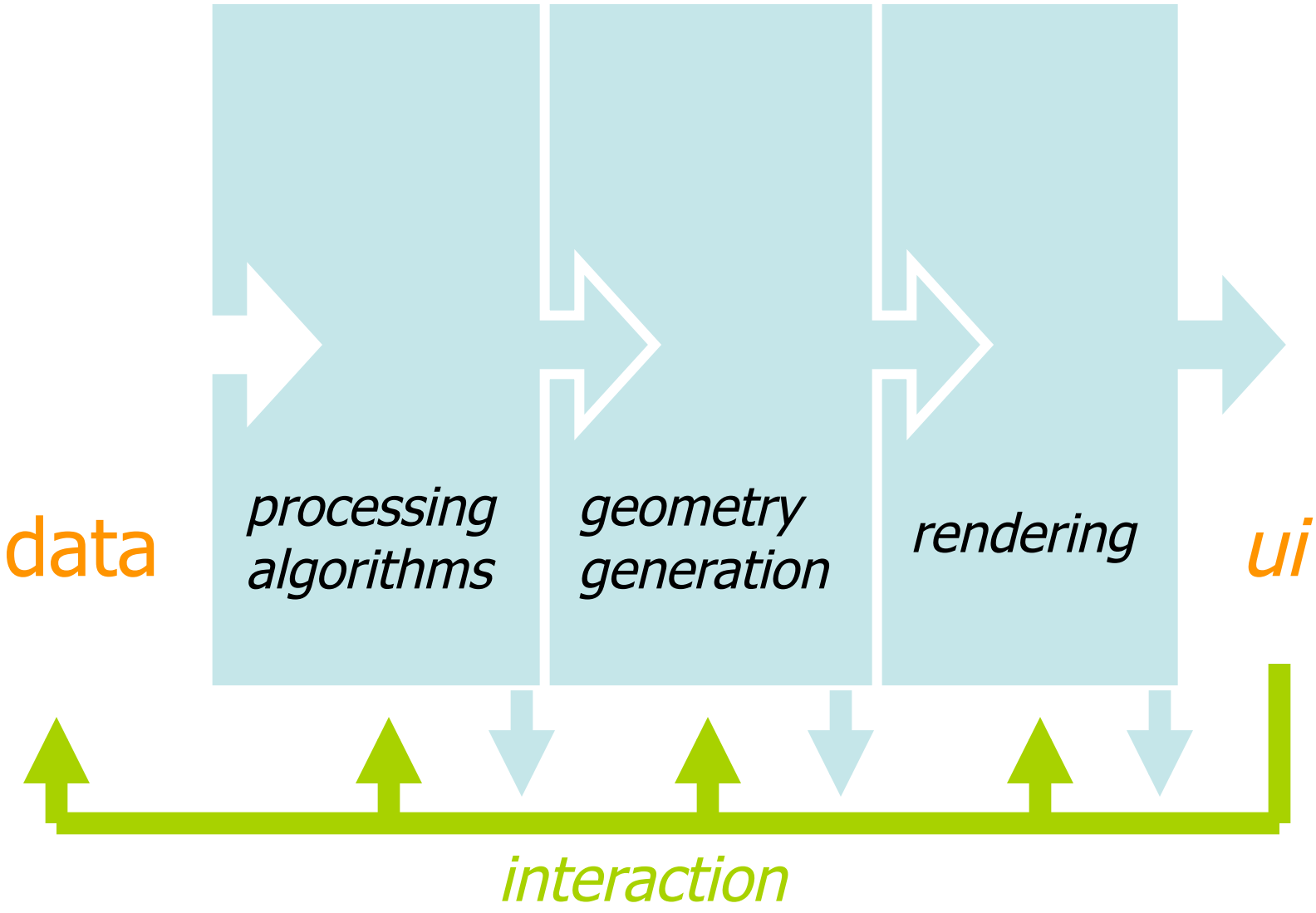
center for advanced computing research

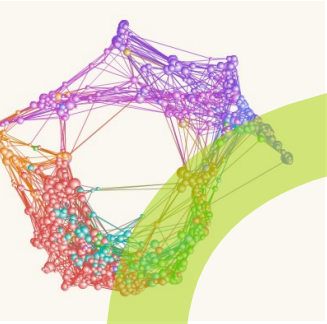
caltech

quick review:
THE VISUALIZATION PROCESS

usual visualization “engine”

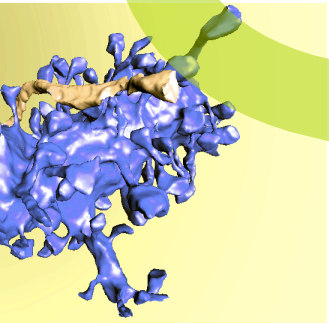


data: geometric structure

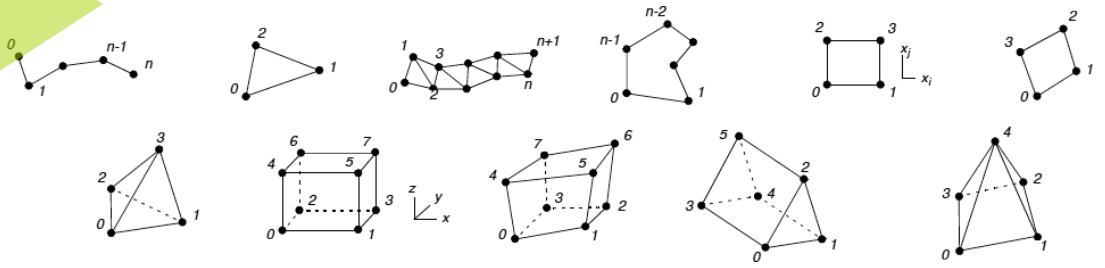


abstract multi-dimensional data records

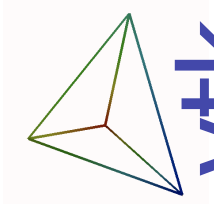
MPG Cylinders Horsepower Weight Acceleration Year Origin
8. 50. 4 2.8 8.2 4 40. 250. 4 1500. 5500. 4 5. 30. 4 69.5 82.5 4 .8 3.2 3
18.000000 8.000000 130.000000 3504.000000 12.000000 70.000000 1.000000
15.000000 8.000000 165.000000 3693.000000 11.500000 70.000000 1.000000
18.000000 8.000000 150.000000 3436.000000 11.000000 70.000000 1.000000
16.000000 8.000000 150.000000 3433.000000 12.000000 70.000000 1.000000
17.000000 8.000000 140.000000 3449.000000 10.500000 70.000000 1.000000
... ...



2d/3d data + scalar/vector/tensor + time



vtk sample: pyramid.vtk

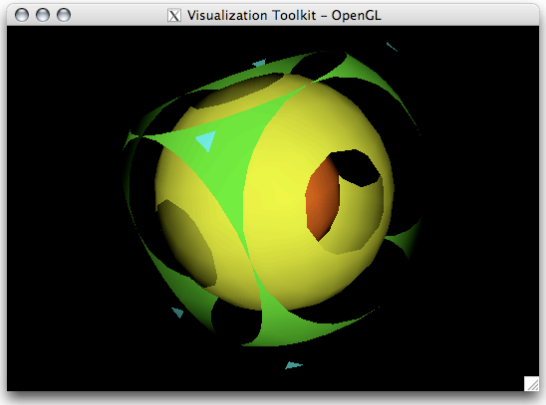


```
# vtk DataFile Version 2.0
My Tet-Pyramid Example
ASCII
DATASET UNSTRUCTURED_GRID
POINTS 4 float
0.0 0.0 0.0
1.0 0.0 0.0
0.5 0.0 0.7
0.5 0.6 0.7
CELLS 1 5
4 0 1 2 3
CELL_TYPES 1
10
POINT_DATA 4
SCALARS vertexData float 1
LOOKUP_TABLE default
0.1
0.2
0.3
0.4
CELL_DATA 1
SCALARS tetData int 1
LOOKUP_TABLE default
1
```

vtk sample: volume.vti

```
<?xml version="1.0"?>
<VTKFile type="ImageData" version="0.1"
      byte_order="LittleEndian">
<ImageData WholeExtent="0 3 0 3 0 3" Origin="0 0 0"
      Spacing="1 1 1">
<Piece Extent="0 3 0 3 0 3">
<PointData Scalars="vertexData">
<DataArray type="Float32" Name="scalarData"
      format="ascii">
0 1 2 3 1 2 3 4 2 3 4 8 3 6 9 11
2 3 4 5 5 6 7 8 3 4 5 6 4 5 6 7
3 4 5 6 3 4 5 6 4 5 6 7 6 7 8 9
2 3 4 5 2 3 4 5 3 4 5 6 4 5 6 7
</DataArray>
</PointData>
<CellData Scalars="cellData" Normals="cell_ normals">
<DataArray type="Int32" Name="cellData" format="ascii">
1 3 9 2 8 16 3 9 27
2 3 4 6 7 8  6 9 10
0 1 2 0 2 4  1 2 3
</DataArray>
</CellData>
</Piece>
</ImageData>
</VTKFile>
```

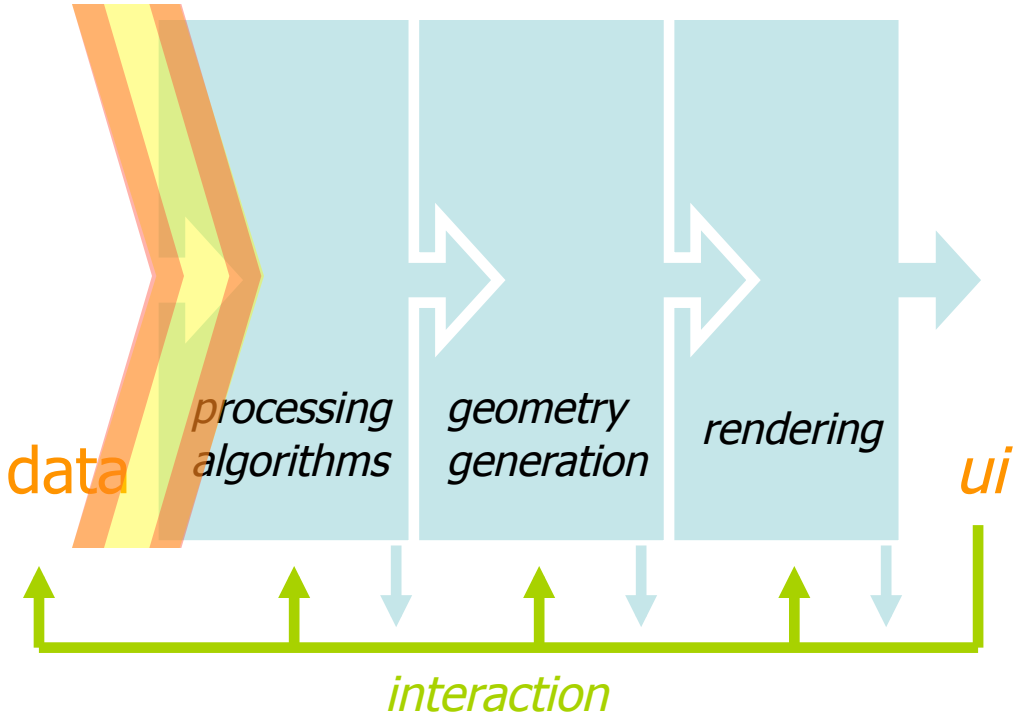
vtkpython: iso.py




```
#! /usr/bin/python
# load VTK extensions
import vtk

# create a rendering window and renderer
renderer =    vtk.vtkRenderer()
myWindowRenderer = vtk.vtkRenderWindow()
myWindowRenderer.AddRenderer(renderer)
myWindowRenderer.SetSize(640,480)

myInteractiveWindow =   vtk.vtkRenderWindowInteractor()
myInteractiveWindow.SetRenderWindow(myWindowRenderer)

# read mydata from volume.vti file
mydata= vtk.vtkXMLImageDataReader()
mydata.SetFileName("volume.vti")

# create filter
mydataIso= vtk.vtkMarchingCubes()
mydataIso.SetInput(mydata.GetOutput())
mydataIso.SetValue(0,0.1)
mydataIso.SetValue(1,0.3)
mydataIso.SetValue(2,0.5)
mydataIso.SetValue(3,0.7)

# pipe resuts to polymapper, and add actor
mydataMapper= vtk.vtkPolyDataMapper()
mydataMapper.SetInput(mydataIso.GetOutput())
mydataActor = vtk.vtkActor()
mydataActor.SetMapper(mydataMapper)
# assign our actor to the renderer
renderer.AddActor(mydataActor)

# enable user interface interactor
myInteractiveWindow.Initialize()
myInteractiveWindow.Start()
```

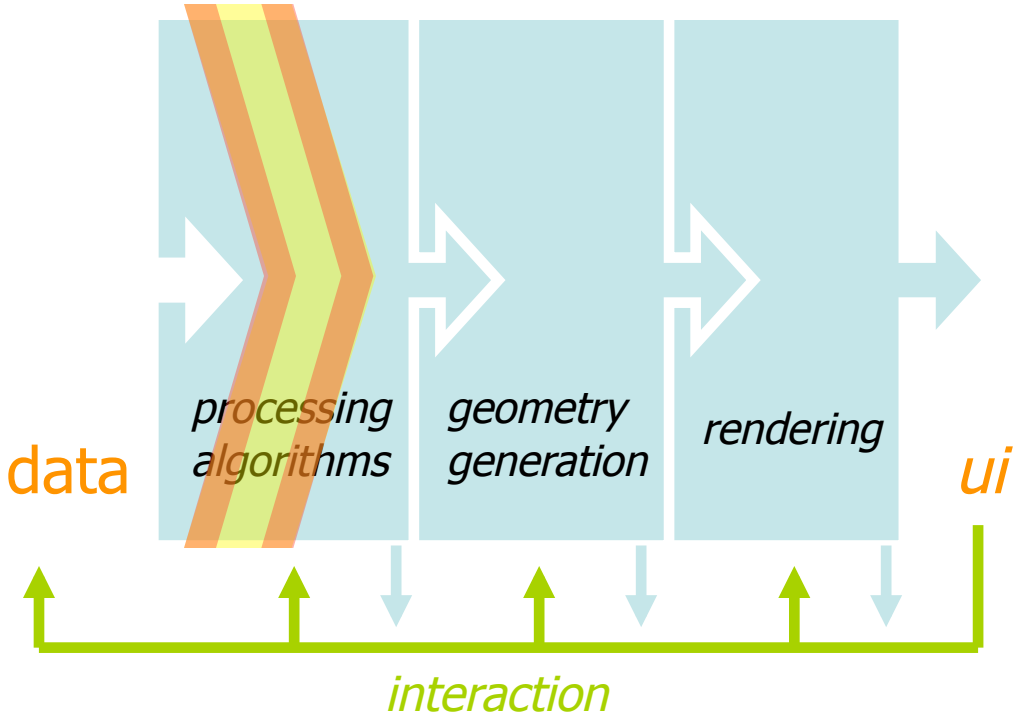
closer look:
BOTTLENECKS

visualization bottlenecks



- data size
- data format
  - *xml*

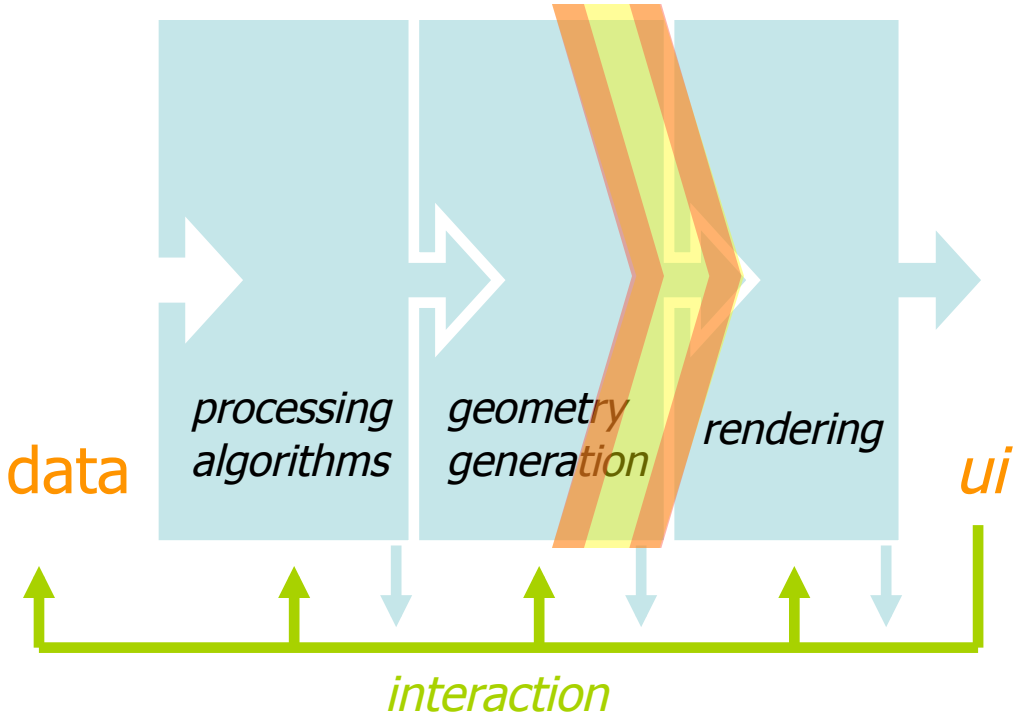
visualization bottlenecks



computation

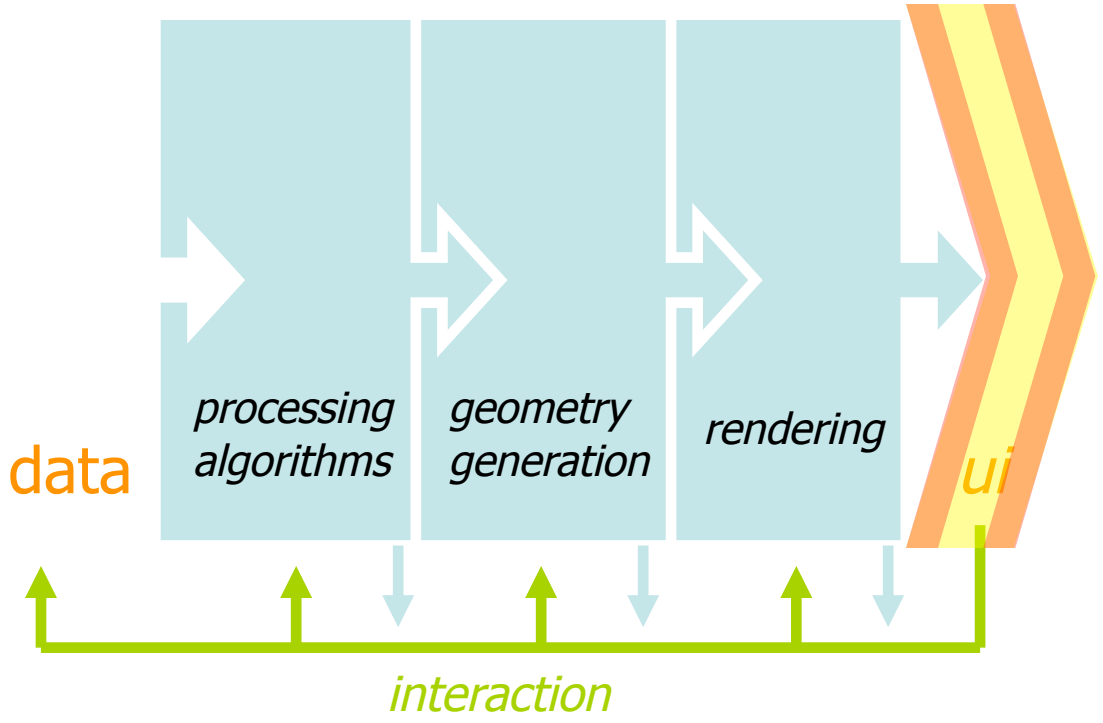
power

visualization bottlenecks



- number of triangles
  (base rendering units)
- number voxels

visualization bottlenecks



- knowledge level of "end user"
- complexity of data base

addressing: bottlenecks:
lod vs parallelism

addressing *throughput bottlenecks*

- level of detail (LOD)
  - requires preprocessing
  - requires larger storage (*original+…*)

- parallel processing/rendering
  - requires a parallel system
  - increases sw complexity
  - less likely to be "portable"

lod: decimation

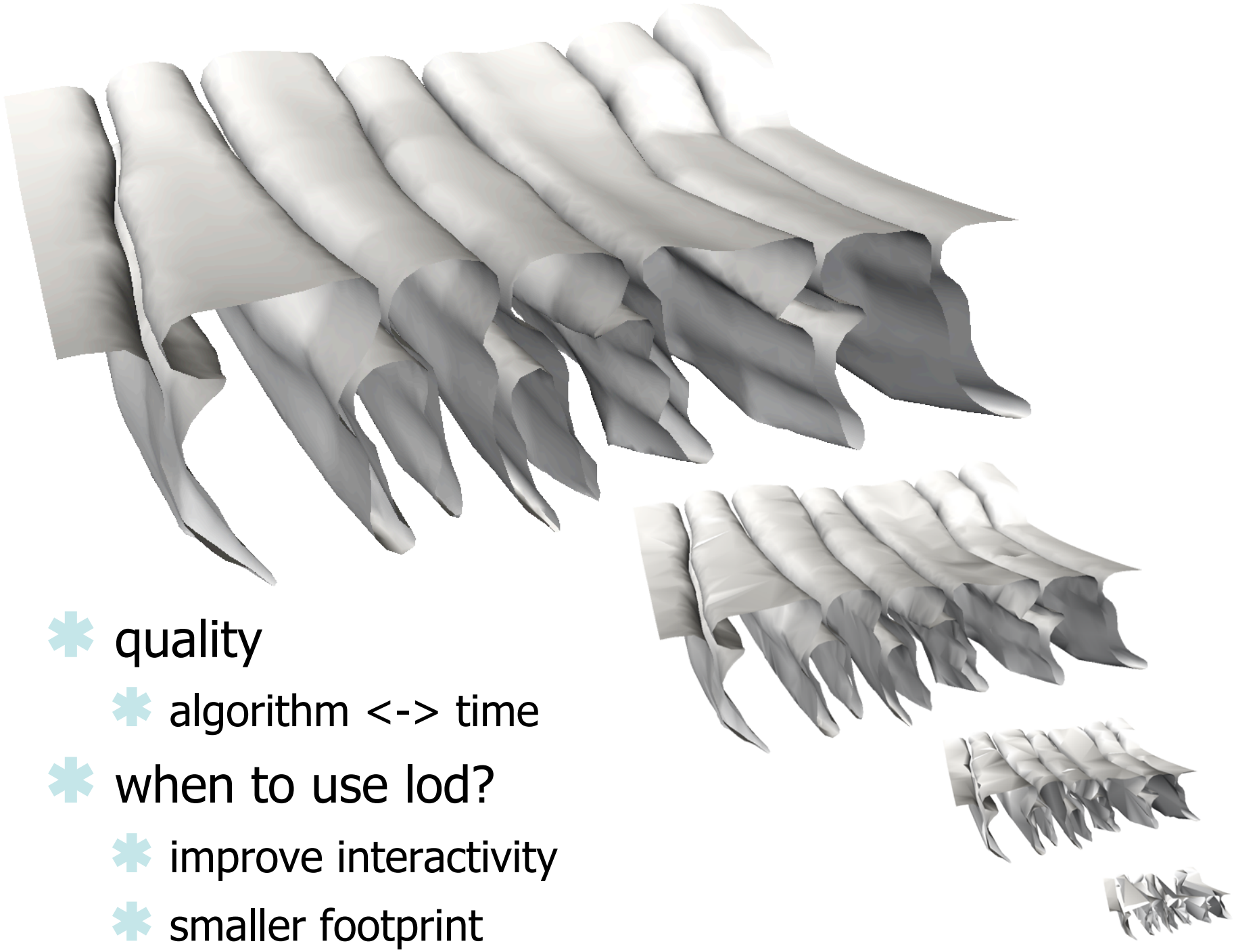
25365

12681

50%

1011

4%



- quality
  - algorithm <-> time
- when to use lod?
  - improve interactivity
  - smaller footprint

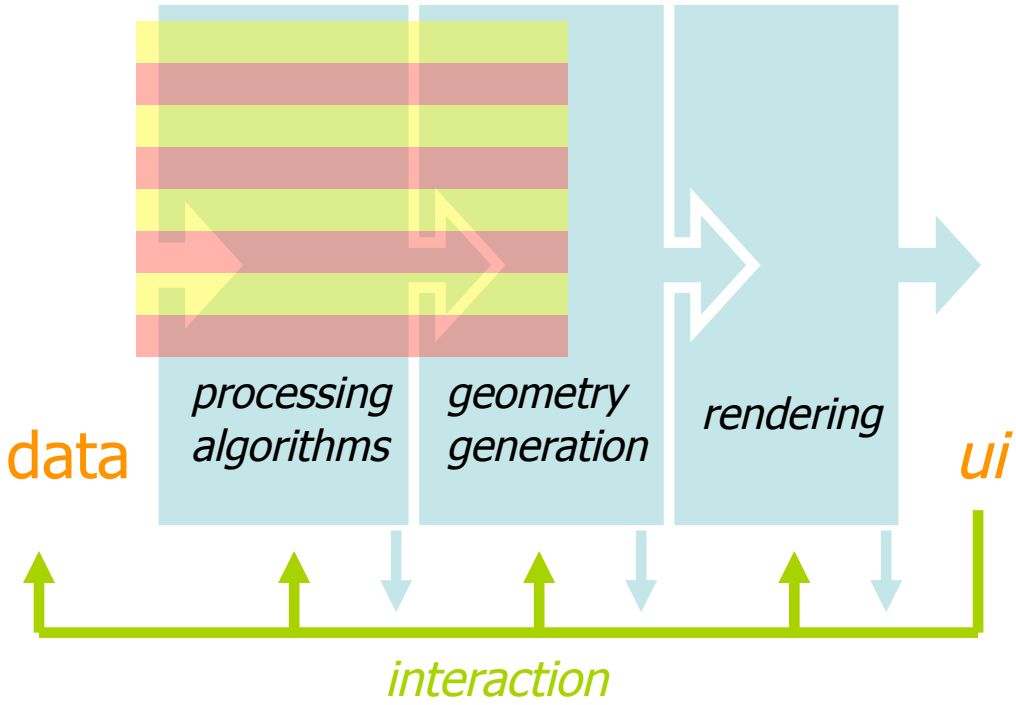
addressing: bottlenecks:
lod vs parallelism

addressing *throughput bottlenecks*

- level of detail (LOD)
  - requires preprocessing
  - requires larger storage (*original+…*)

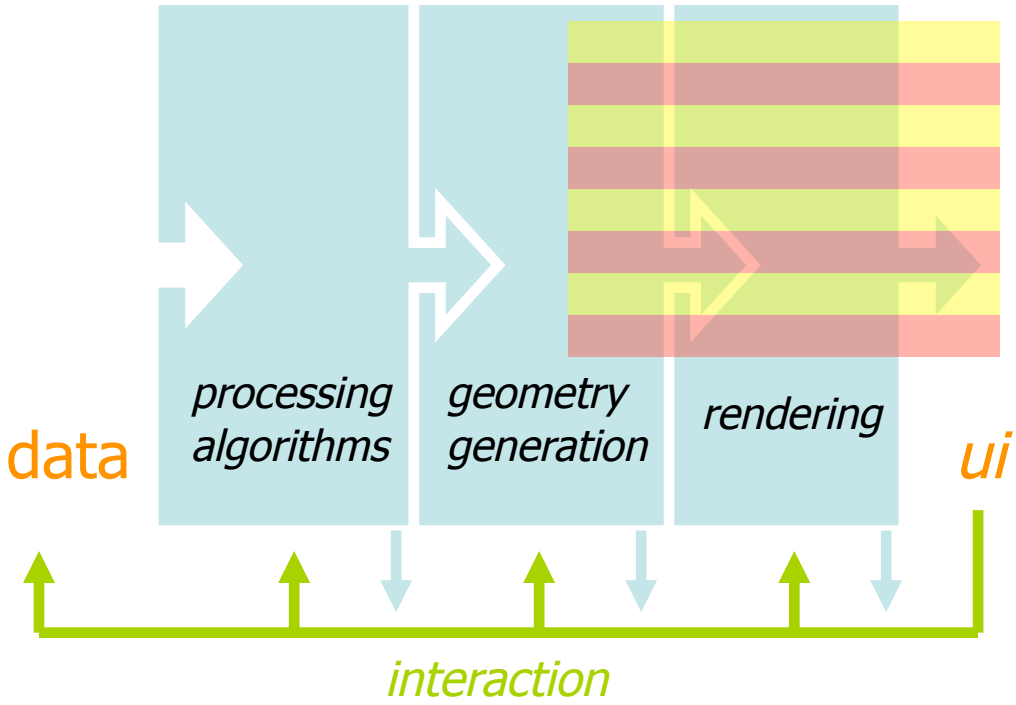
- parallel processing/rendering
  - requires a parallel system
  - increases sw complexity
  - less likely to be “portable”

parallel viz...



- + cpus
- data?
- seams?

parallel viz...

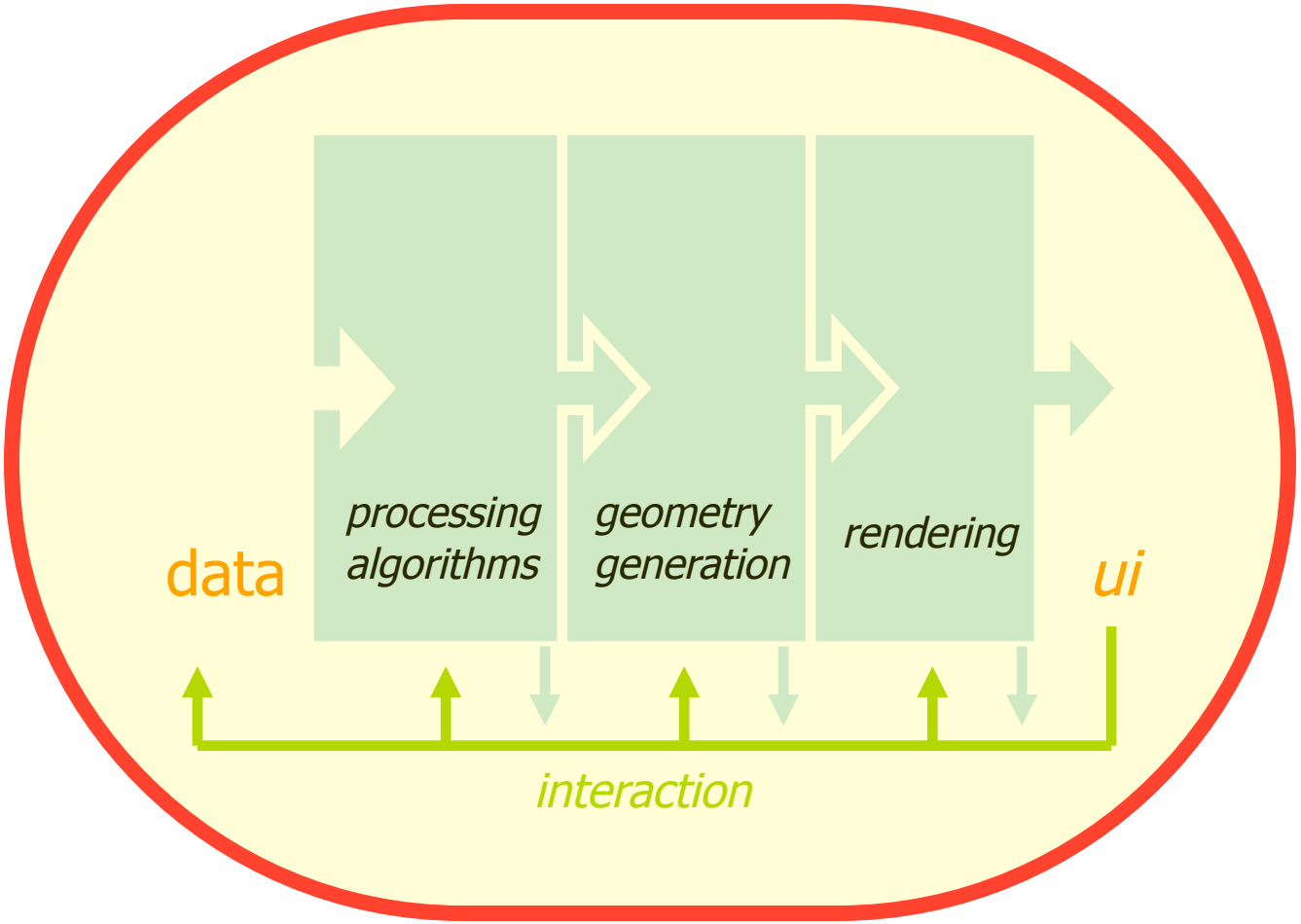


- + gpus
- screen?
- space?

addressing: bottlenecks:

leverage other peoples work: parallelism

visualization system



- Paraview[VTK]
- LLNL VisIt[VTK]
- EnSight[$]
- OpenDX
  - *IBM's DataExplorer*
- Mollegro, ...

tools:

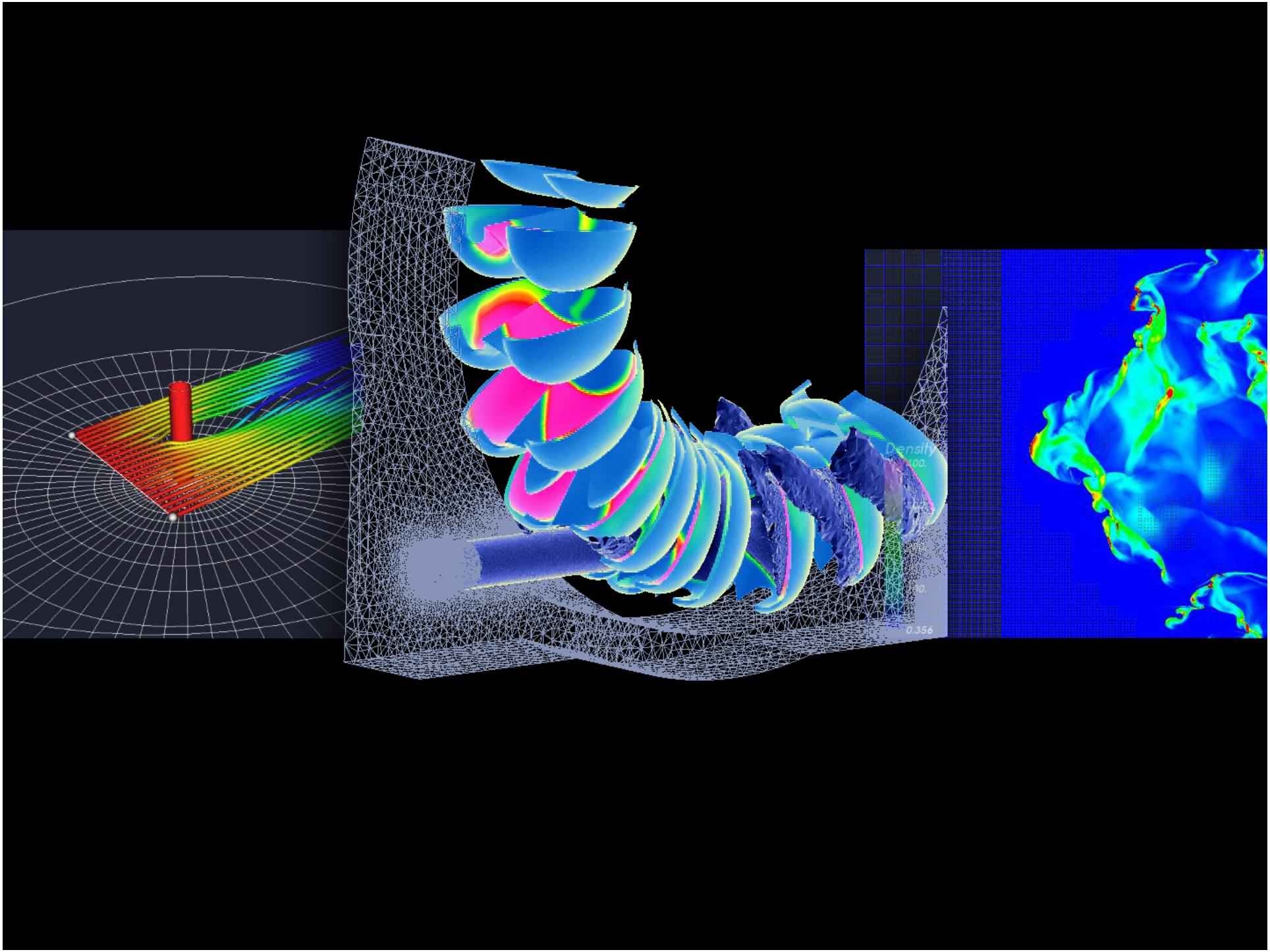
PARAVIEW VTK

paraview

paraview.org

- vtk based!
- active community
  - mailing list + wiki
  - lead at kitware: *berk geveci*
    - sandia national lab
    - los alamos national lab, army research lab
- parallel!
- QT based (from version 3.0)
  - 3.4.0 available in most platforms

quick demo:
PARAVIEW


Density
0.356

tools:

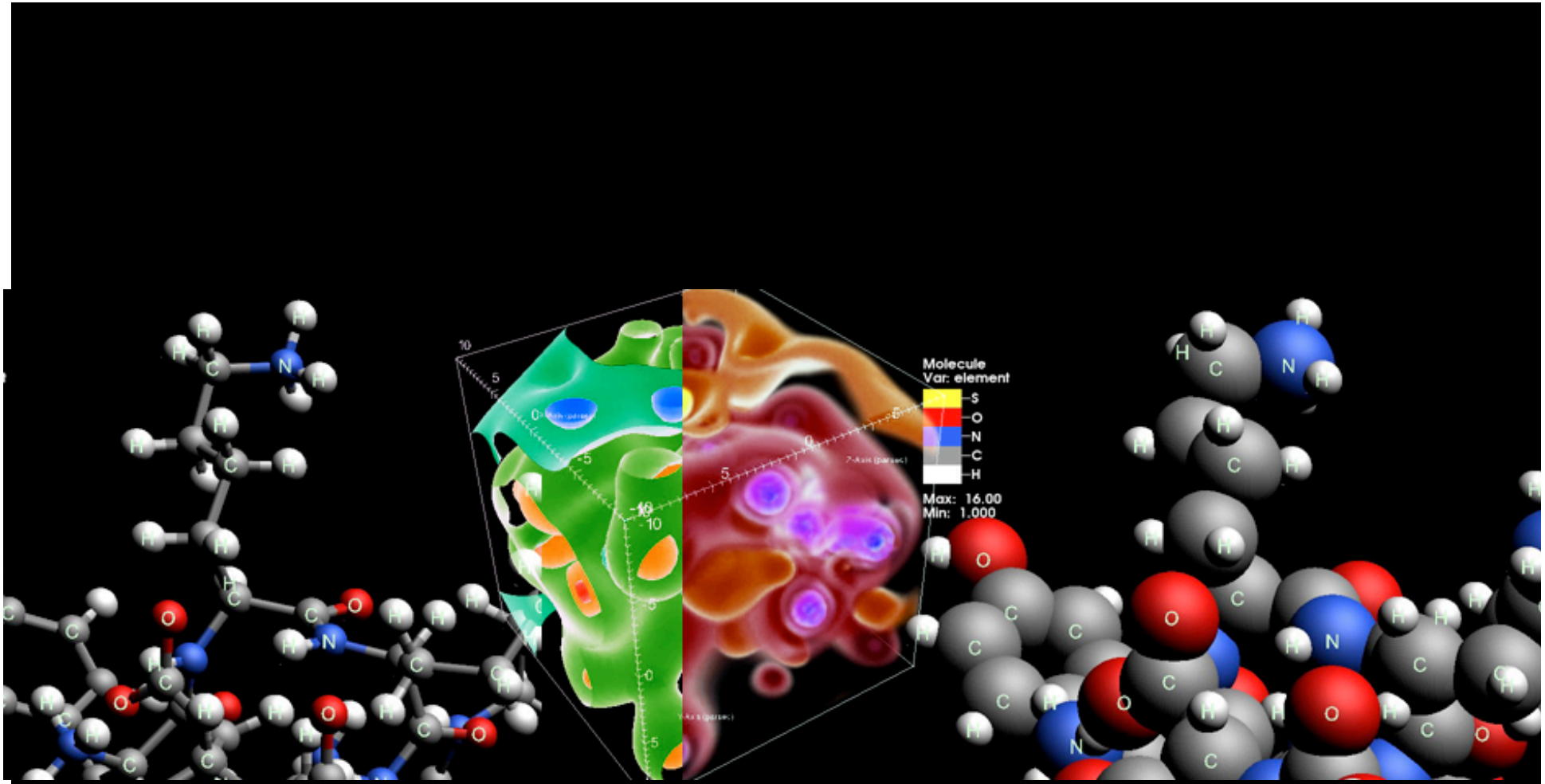
VISIT VTK

llnl's visit!

llnl.gov/visit

- vtk based!
- active development
  - very responsive
  - lawrence-livermore national lab (asci/doe)
- designed for large data
- parallel!
- presets for large lab machines
- easily scriptable via python
- simple docs (minimal pdf)

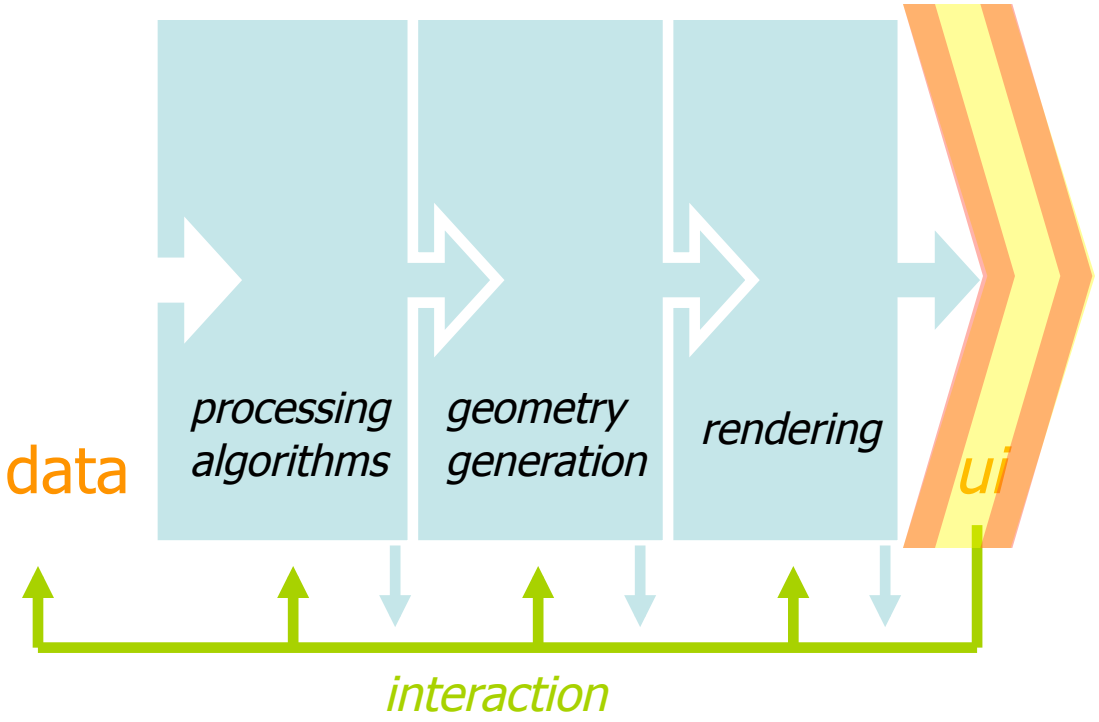
demo:
VISIT


Molecule
Var: element
S
O
N
C
H
Max: 16.00
Min: 1.000

why paraview[PV]? (visit[V!]?)

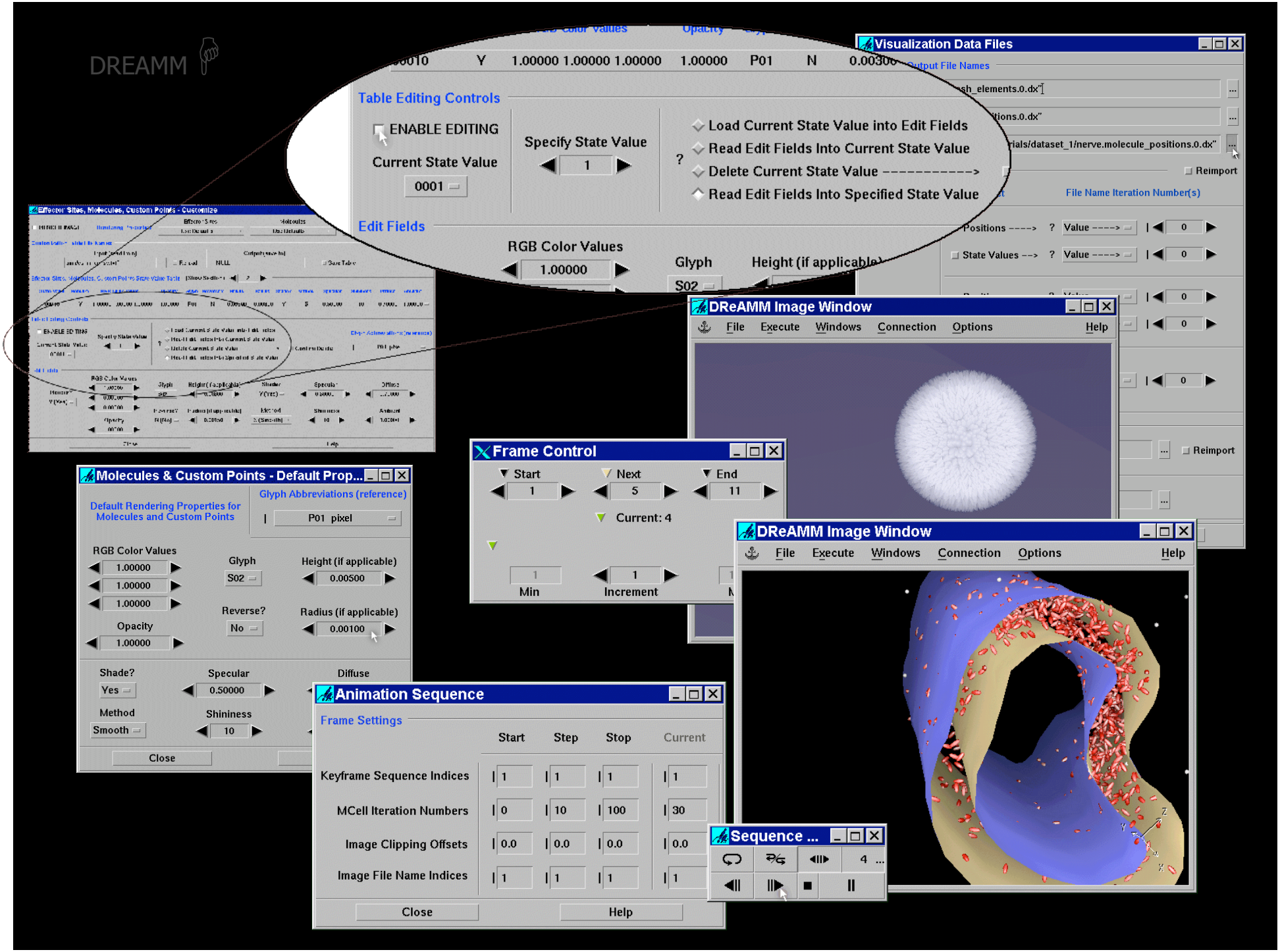
- paraview/visit can handle large data!
  - parallel — PV: 👍 V!: 👍👍
  - stable — PV: 👍 V!: 👍👍
  - gui — PV: 👍👍👍 V!: 👍
  - lod — PV: 👍👍 V!: 👍
- many filters (all of vtk), open source, binaries for major platforms, 64 bit versions, actively being developed, scriptable (*python!*), …
- *possible to extend and/or script*
  - learning curve
  - hard to get everything

visualization bottlenecks



case study: *gui design*

MCELL BIO VIEWER


DREAMM
Table Editing Controls
ENABLE EDITING
Current State Value
0001
Specify State Value
1
Load Current State Value into Edit Fields
Read Edit Fields Into Current State Value
Delete Current State Value
Read Edit Fields Into Specified State Value
Edit Fields
RGB Color Values
1.00000
Glyph
S02
Height (if applicable)
Visualization Data Files
Output File Names
Reimport
File Name Iteration Number(s)
DReAMM Image Window
File
Execute
Windows
Connection
Options
Help
Frame Control
Start
Next
End
1
5
11
Current: 4
Min
Increment
Molecules & Custom Points - Default Prop...
Default Rendering Properties for Molecules and Custom Points
Glyph Abbreviations (reference)
P01 pixel
RGB Color Values
1.00000
Glyph
S02
Height (if applicable)
0.00500
Reverse?
No
Radius (if applicable)
0.00100
Opacity
Shade?
Yes
Specular
0.50000
Diffuse
Method
Smooth
Shininess
10
Close
Animation Sequence
Frame Settings
Start
Step
Stop
Current
Keyframe Sequence Indices
MCell Iteration Numbers
Image Clipping Offsets
Image File Name Indices
Close
Help
Sequence ...

GUI

intuitive

simple

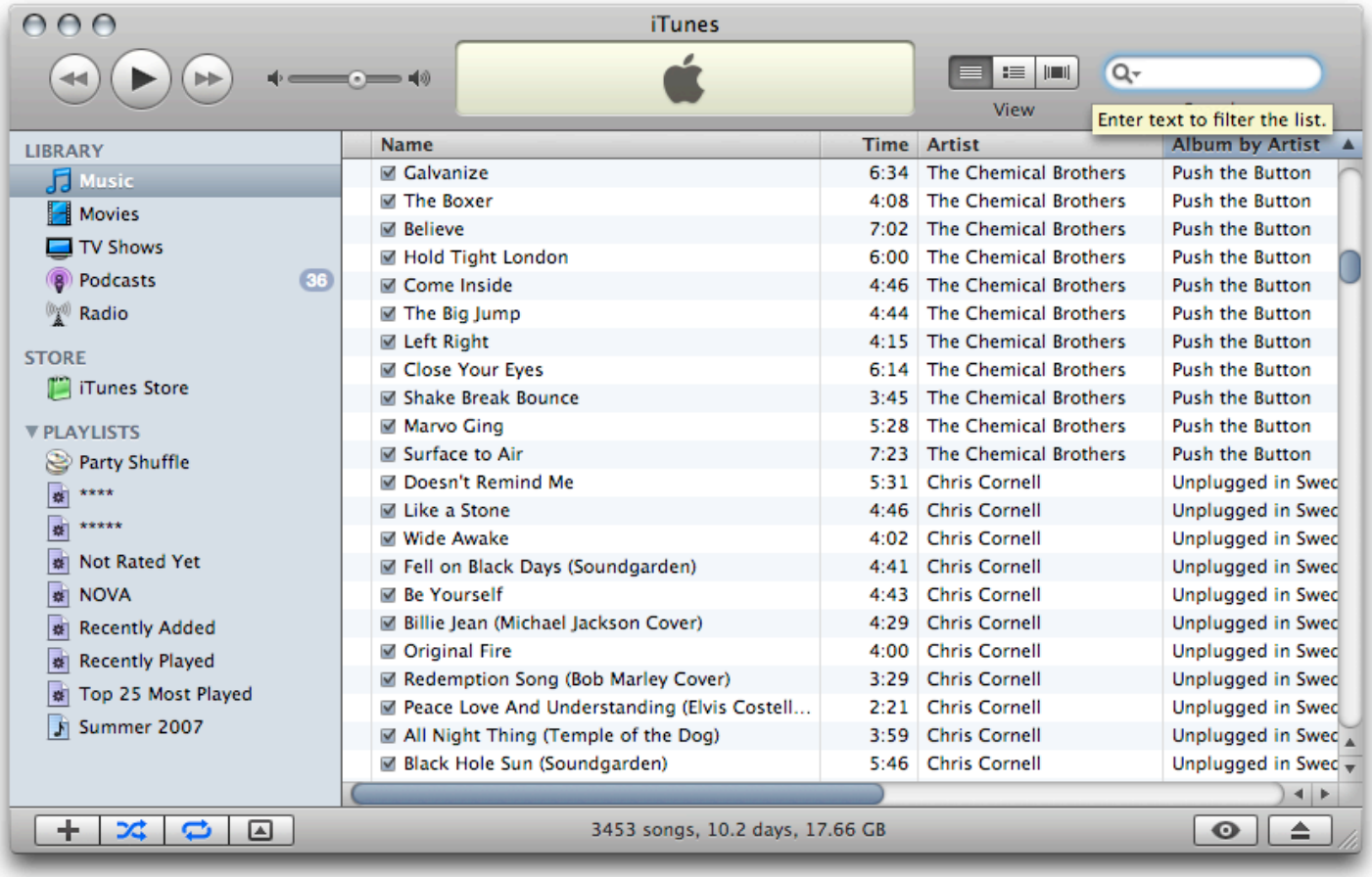
interactive

effective

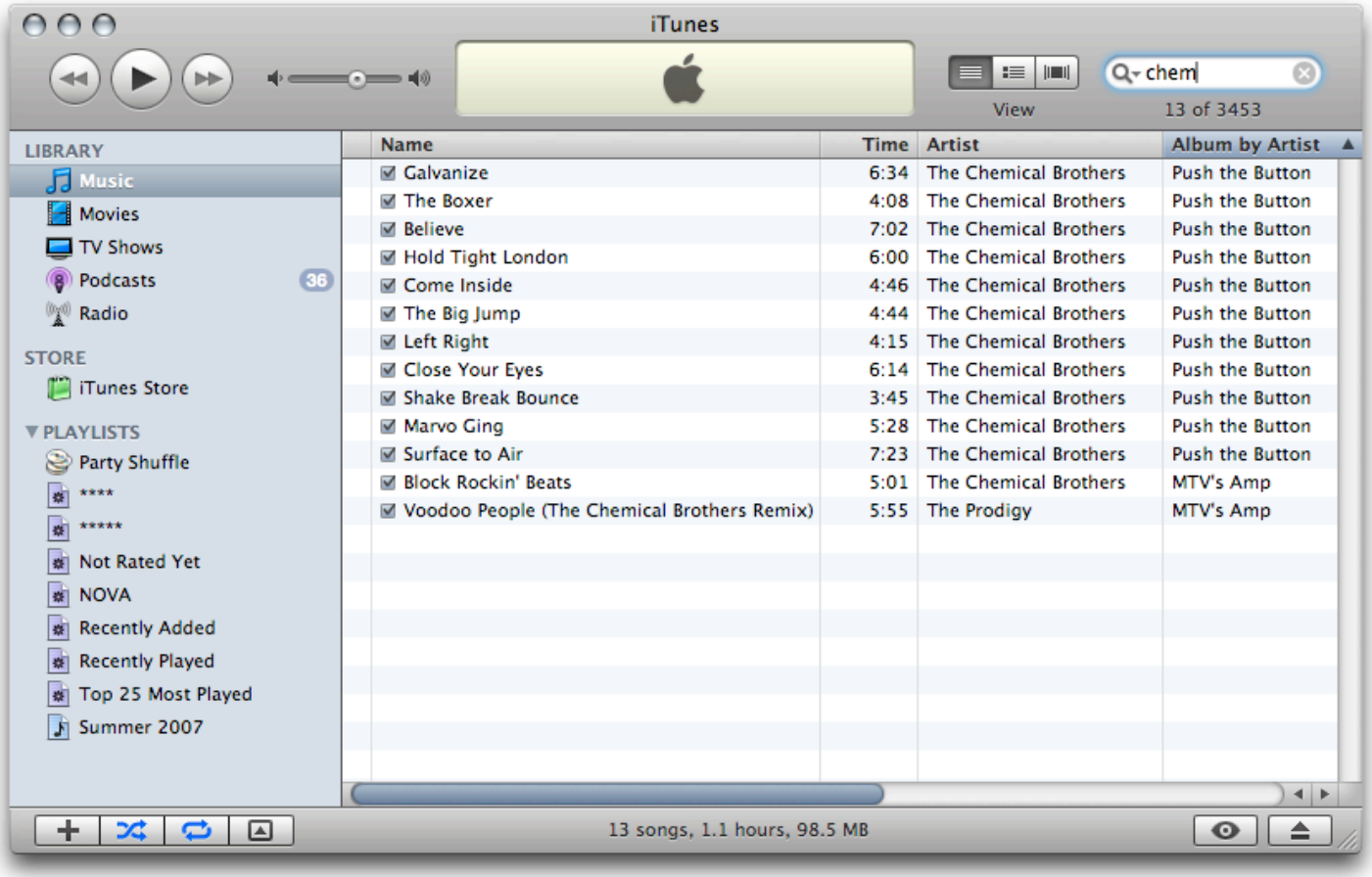
* who is the user?
* what is the task?

. . . inspiration

GUI


iTunes
View
Enter text to filter the list.
LIBRARY
Music
Movies
TV Shows
Podcasts
36
Radio
STORE
iTunes Store
PLAYLISTS
Party Shuffle
****
*****
Not Rated Yet
NOVA
Recently Added
Recently Played
Top 25 Most Played
Summer 2007
Name
Time
Artist
Album by Artist
Galvanize 6:34 The Chemical Brothers Push the Button
The Boxer 4:08 The Chemical Brothers Push the Button
Believe 7:02 The Chemical Brothers Push the Button
Hold Tight London 6:00 The Chemical Brothers Push the Button
Come Inside 4:46 The Chemical Brothers Push the Button
The Big Jump 4:44 The Chemical Brothers Push the Button
Left Right 4:15 The Chemical Brothers Push the Button
Close Your Eyes 6:14 The Chemical Brothers Push the Button
Shake Break Bounce 3:45 The Chemical Brothers Push the Button
Marvo Ging 5:28 The Chemical Brothers Push the Button
Surface to Air 7:23 The Chemical Brothers Push the Button
Doesn't Remind Me 5:31 Chris Cornell Unplugged in Swec
Like a Stone 4:46 Chris Cornell Unplugged in Swec
Wide Awake 4:02 Chris Cornell Unplugged in Swec
Fell on Black Days (Soundgarden) 4:41 Chris Cornell Unplugged in Swec
Be Yourself 4:43 Chris Cornell Unplugged in Swec
Billie Jean (Michael Jackson Cover) 4:29 Chris Cornell Unplugged in Swec
Original Fire 4:00 Chris Cornell Unplugged in Swec
Redemption Song (Bob Marley Cover) 3:29 Chris Cornell Unplugged in Swec
Peace Love And Understanding (Elvis Costell... 2:21 Chris Cornell Unplugged in Swec
All Night Thing (Temple of the Dog) 3:59 Chris Cornell Unplugged in Swec
Black Hole Sun (Soundgarden) 5:46 Chris Cornell Unplugged in Swec
3453 songs, 10.2 days, 17.66 GB

GUI


iTunes
View
chem
13 of 3453
LIBRARY
Music
Movies
TV Shows
Podcasts
36
Radio
STORE
iTunes Store
PLAYLISTS
Party Shuffle
****
*****
Not Rated Yet
NOVA
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Come Inside 4:46 The Chemical Brothers Push the Button
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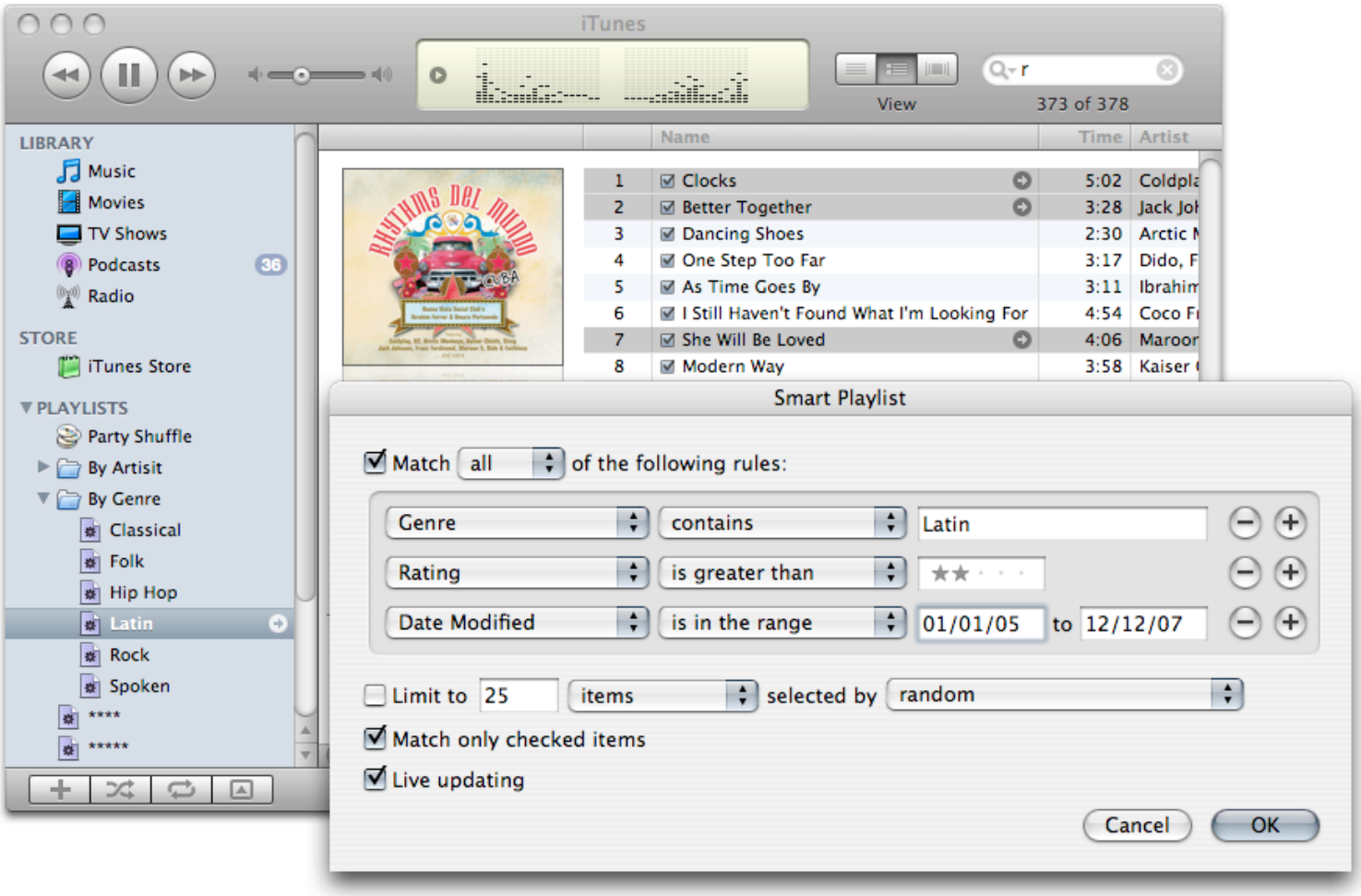
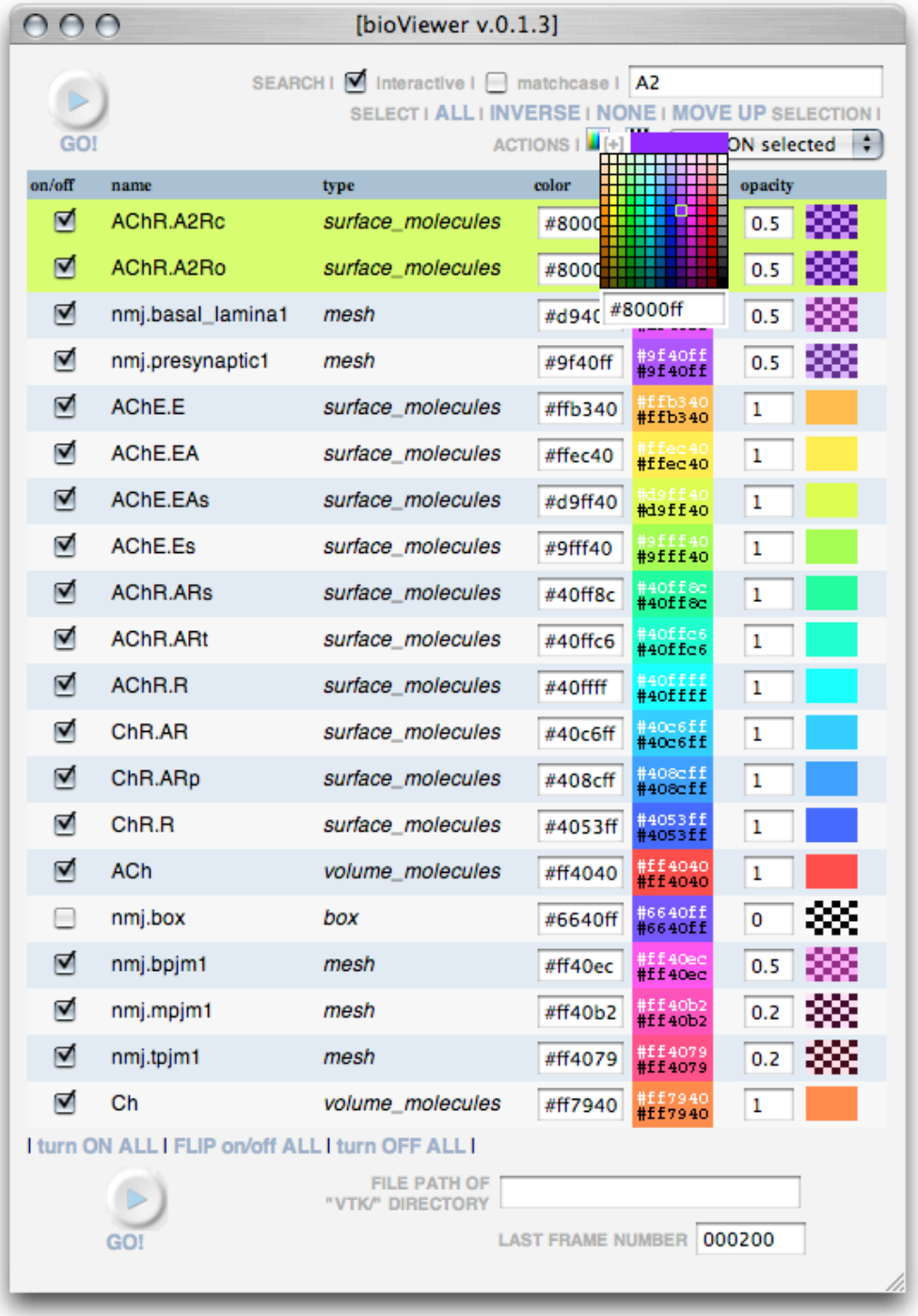
Left Right 4:15 The Chemical Brothers Push the Button
Close Your Eyes 6:14 The Chemical Brothers Push the Button
Shake Break Bounce 3:45 The Chemical Brothers Push the Button
Marvo Ging 5:28 The Chemical Brothers Push the Button
Surface to Air 7:23 The Chemical Brothers Push the Button
Block Rockin' Beats 5:01 The Chemical Brothers MTV's Amp
Voodoo People (The Chemical Brothers Remix) 5:55 The Prodigy MTV's Amp
13 songs, 1.1 hours, 98.5 MB

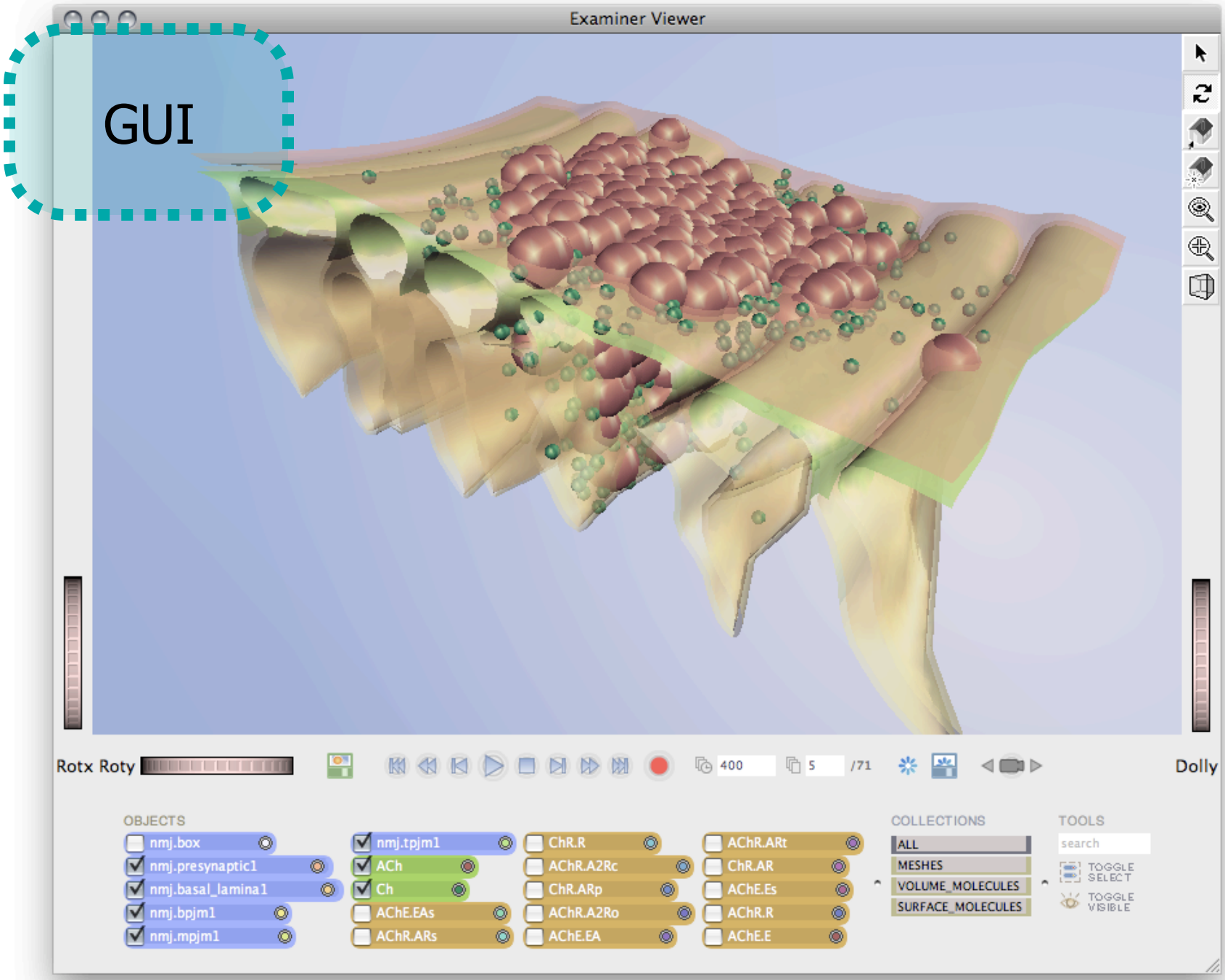
GUI

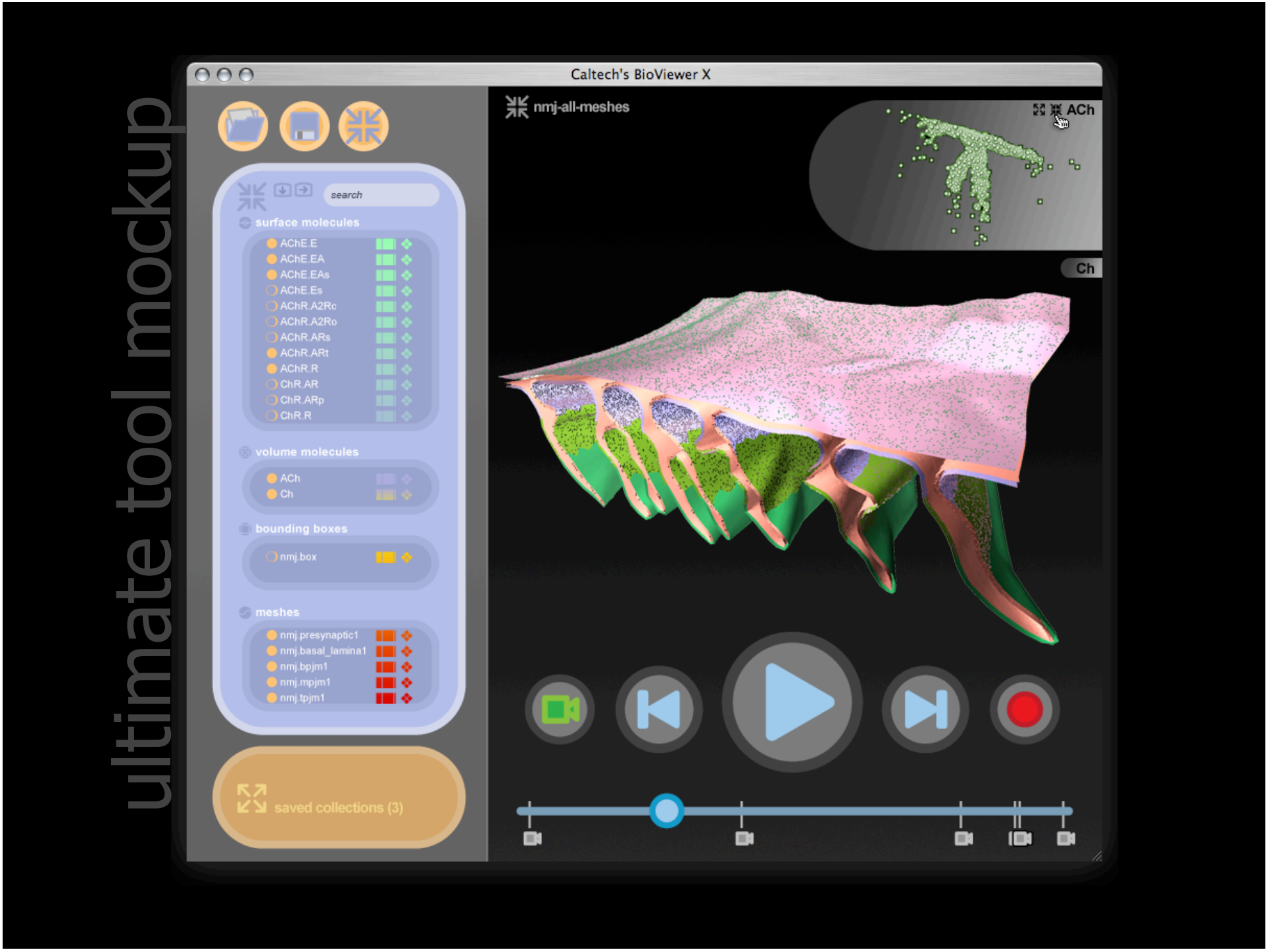

iTunes
View
373 of 378
LIBRARY
Music
Movies
TV Shows
Podcasts
36
Radio
STORE
iTunes Store
PLAYLISTS
Party Shuffle
By Artisit
By Genre
Classical
Folk
Hip Hop
Latin
Rock
Spoken
Name
Time
Artist
1 Clocks 5:02
2 Better Together 3:28
3 Dancing Shoes 2:30
4 One Step Too Far 3:17
5 As Time Goes By 3:11
6 I Still Haven't Found What I'm Looking For 4:54
7 She Will Be Loved 4:06
8 Modern Way 3:58
Smart Playlist
Match all of the following rules:
Genre contains Latin
Rating is greater than
Date Modified is in the range 01/01/05 to 12/12/07
Limit to 25 items selected by random
Match only checked items
Live updating
Cancel
OK

GUI

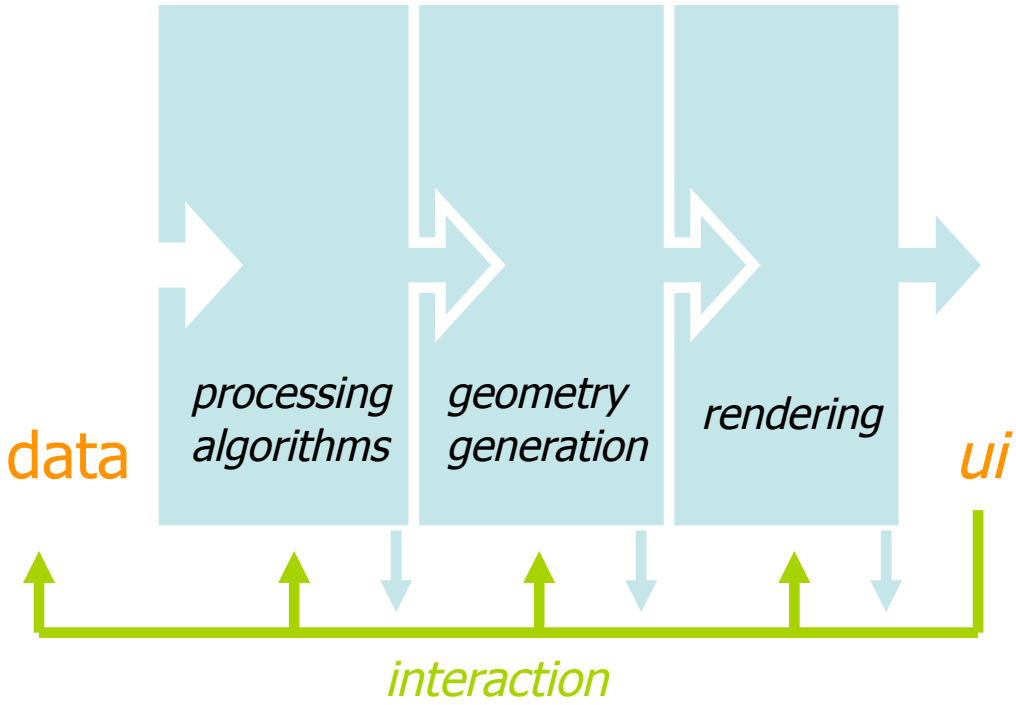


...a first draft


GUI
Examiner Viewer
Rotx Roty
400
5
/71
Dolly
OBJECTS
nmj.box
nmj.presynaptic1
nmj.basal_lamina1
nmj.bpjm1
nmj.mpjm1
nmj.tpjm1
ACh
Ch
AChE.EAs
AChR.ARs
ChR.R
AChR.A2Rc
ChR.ARp
AChR.A2Ro
AChE.EA
AChR.ARt
ChR.AR
AChE.Es
AChR.R
AChE.E
COLLECTIONS
ALL
MESHES
VOLUME_MOLECULES
SURFACE_MOLECULES
TOOLS
search
TOGGLE SELECT
TOGGLE VISIBLE


ultimate tool mockup
Caltech's BioViewer X
nmj-all-meshes
ACh
Ch
search
surface molecules
AChE.E
AChE.EA
AChE.EAs
AChE.Es
AChR.A2Rc
AChR.A2Ro
AChR.ARs
AChR.ARt
AChR.R
ChR.AR
ChR.ARp
ChR.R
volume molecules
ACh
Ch
bounding boxes
nmj.box
meshes
nmj.presynaptic1
nmj.basal_lamina1
nmj.bpjm1
nmj.mpjm1
nmj.tpjm1
saved collections (3)

visualization bottlenecks



what if

there is

not much

to leverage?

exercises

- create your own vtk data file
  - have at least 100 data points/grid points
  - if you have some ascii based data already
    - you can used awk/sed to filter data
    - then you can manually add the vtk tags

- create a movie using paraview!

  (or visit)

- if you feel ambitious, try data explorer, or write a vtk program

thanks!

avyakta.caltech.edu:8888/esci101

methods of computational science

visualization

day ii - bottlenecks/parallel-viz

santiago v lombeyda

center for advanced computing research

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