SimulationIO and yt

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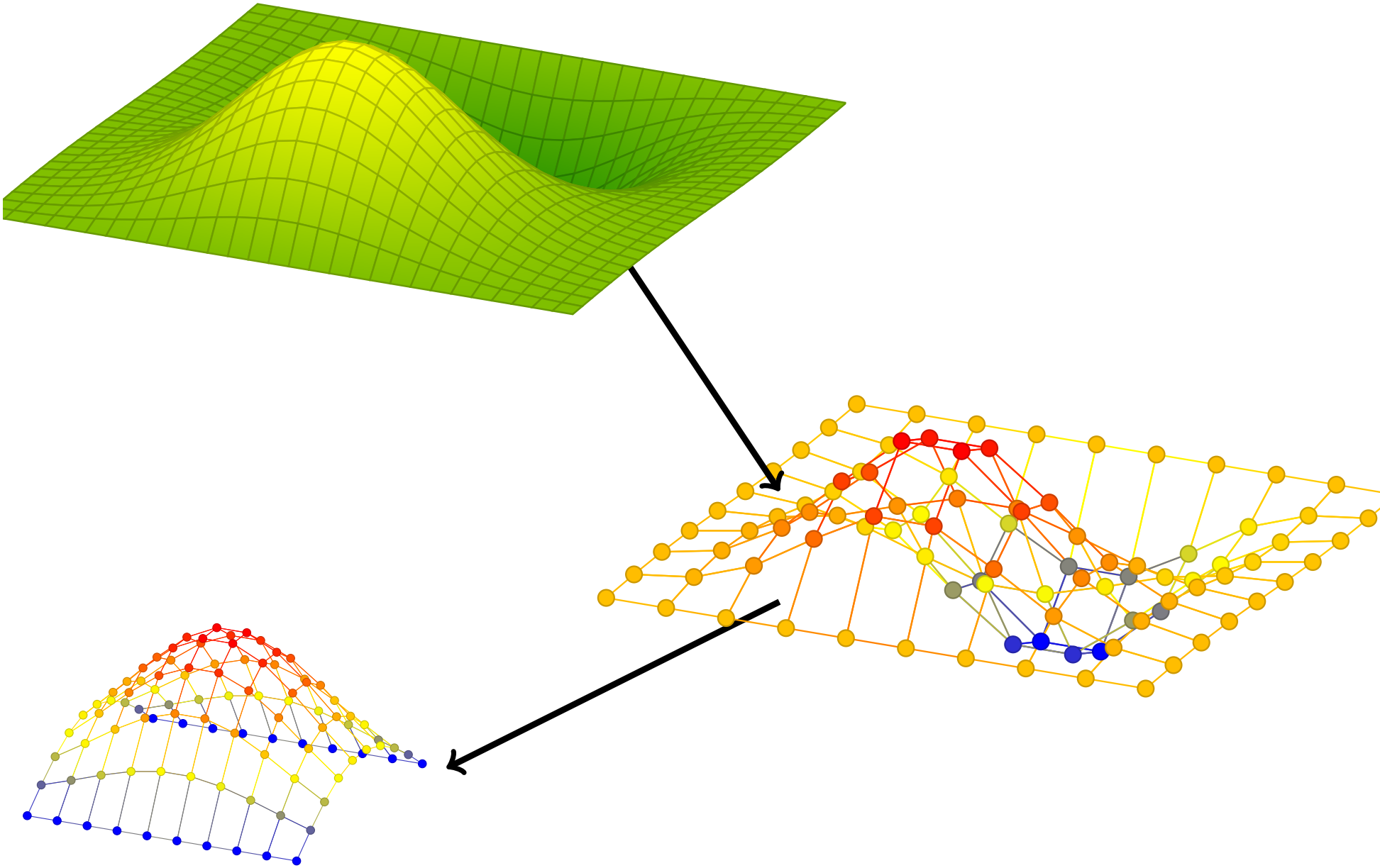
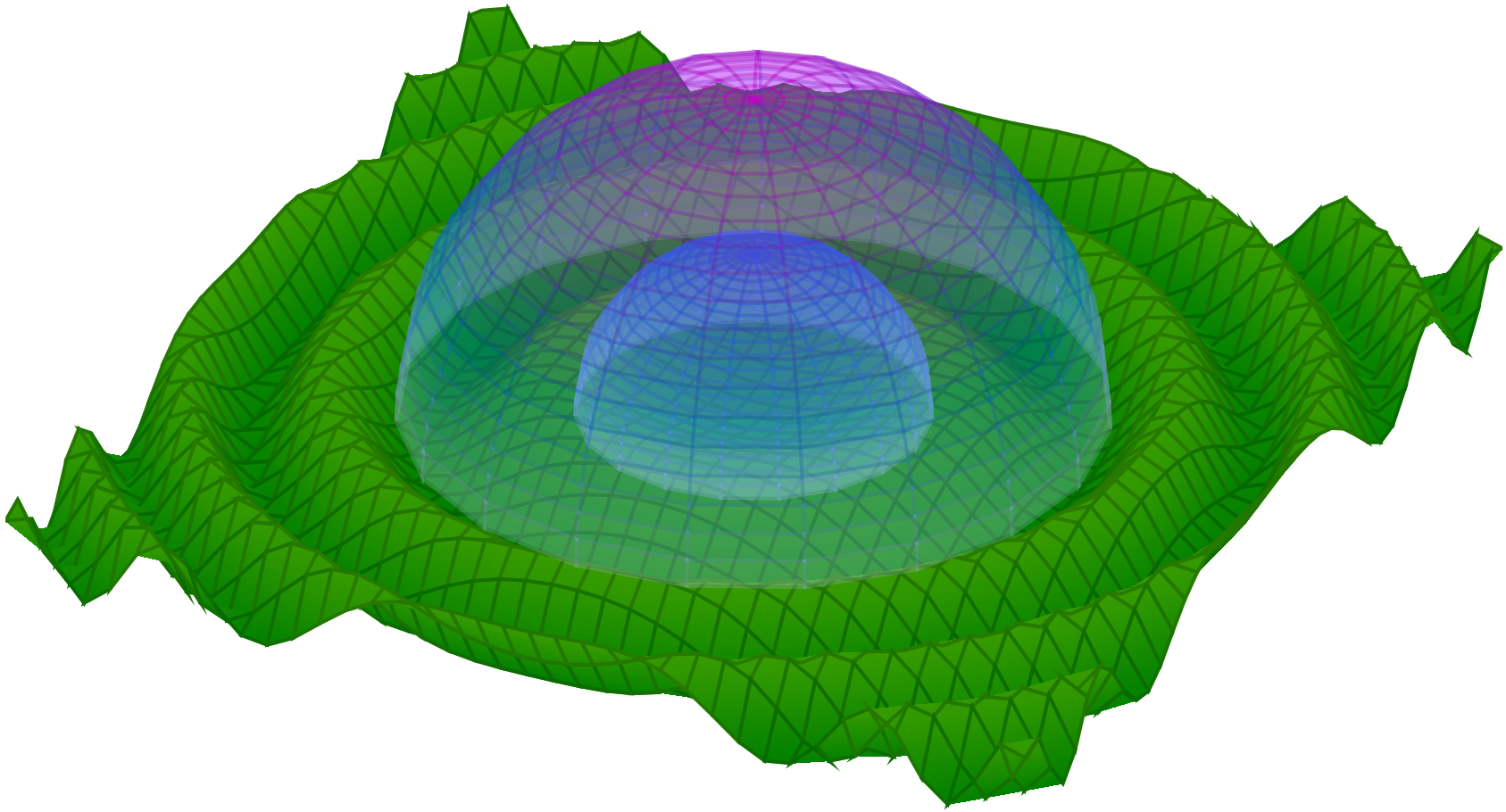
What are they?

- SimulationIO is a library
  - Written by Erik Schnetter
  - Open source
  - Meant to be a *high-level* description of the output of potentially many simulations
  - Abstracts away simulation details
  - Describes an API API
  - Uses category theory to cleanly remove ambiguities
- yt is a visualization (and data analysis) toolkit
  - Open source
  - Community driven
  - Written in Python
  - Very hack-able

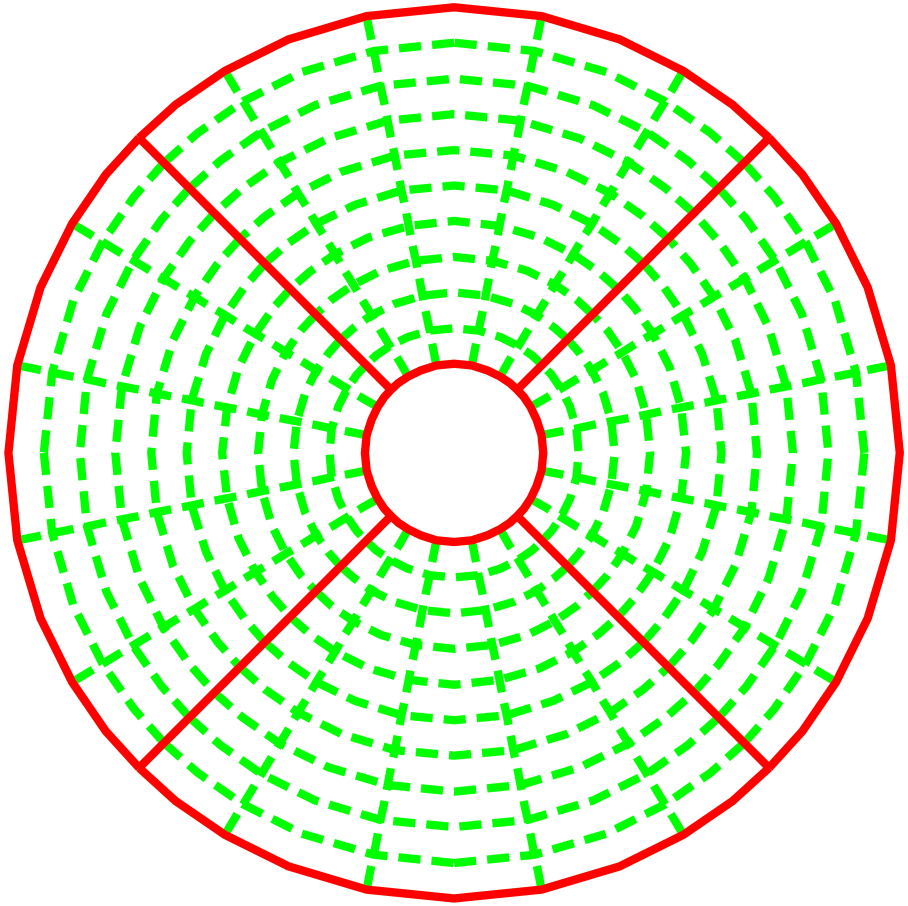
What do we care about in a simulation?

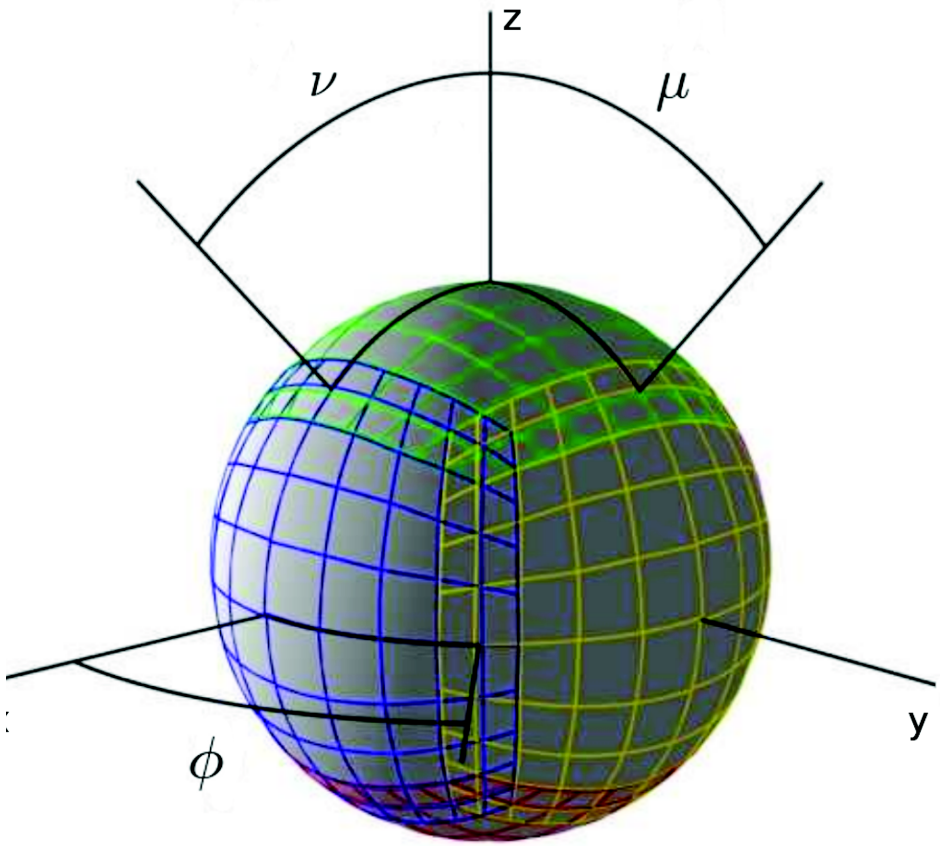


What do we care about in a simulation?



What do we care about in a simulation?

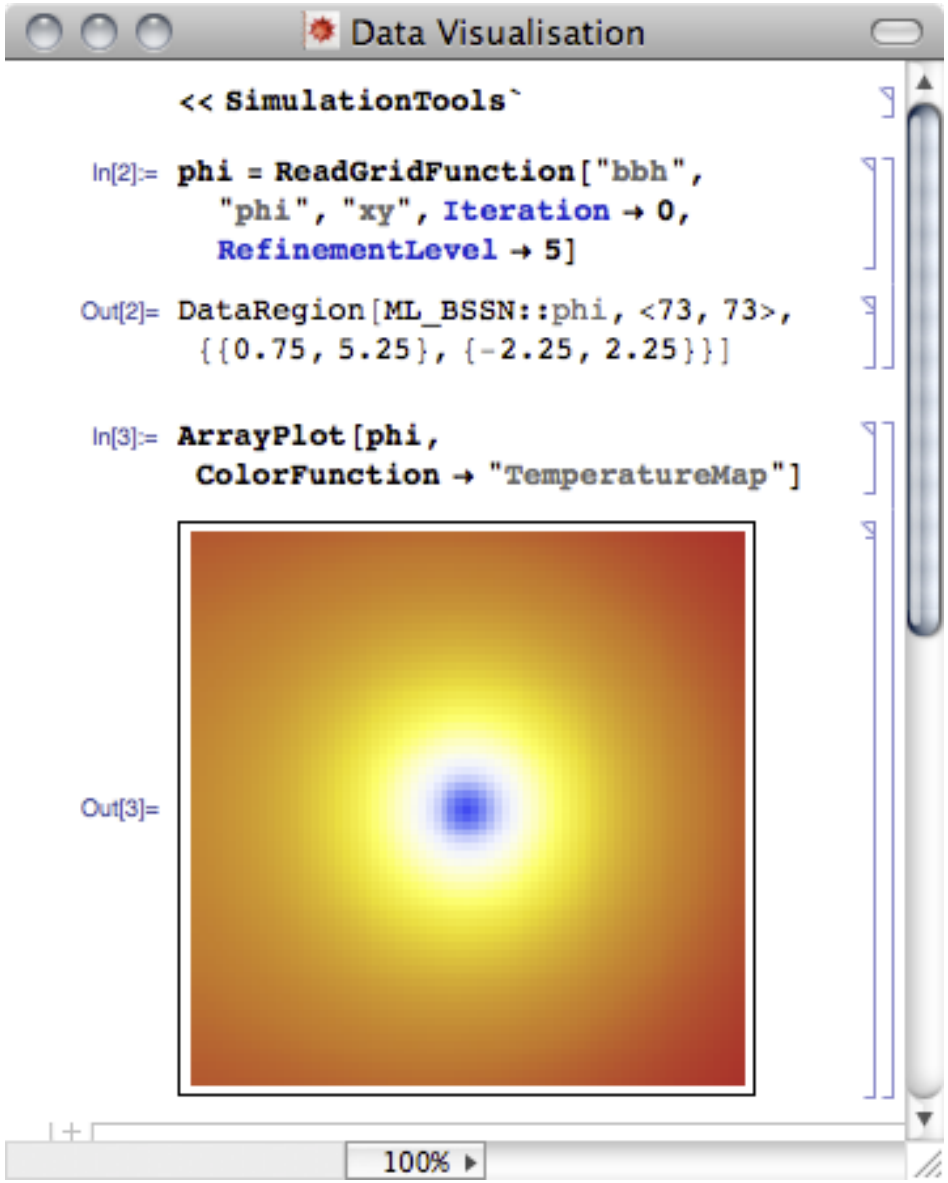




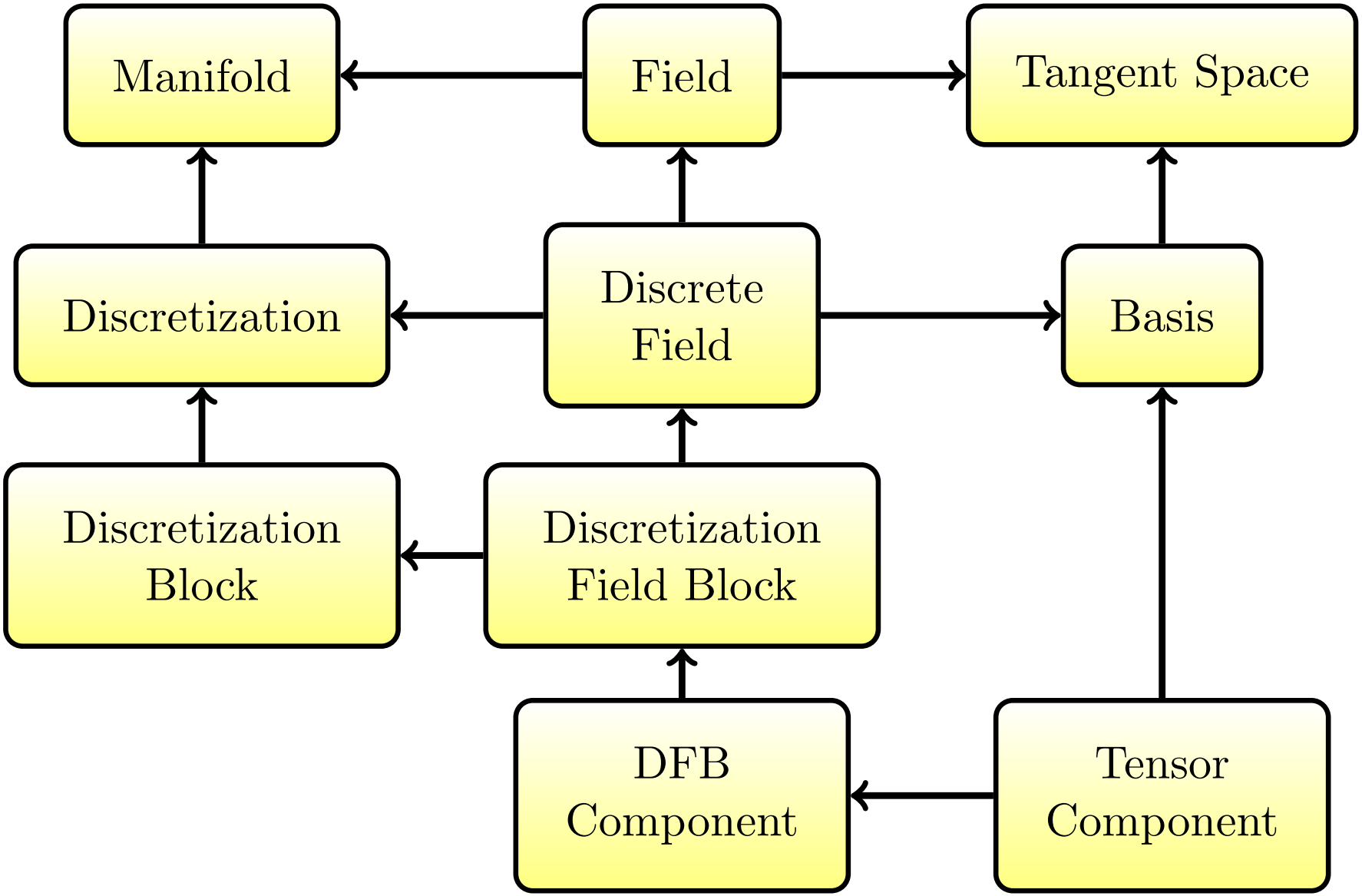
Schnetter *et al* 2006 Class. *Quantum Grav.* **23** S553
Pollney *et al* 2011 *Phys. Rev. D* **83** 044045

Other efforts

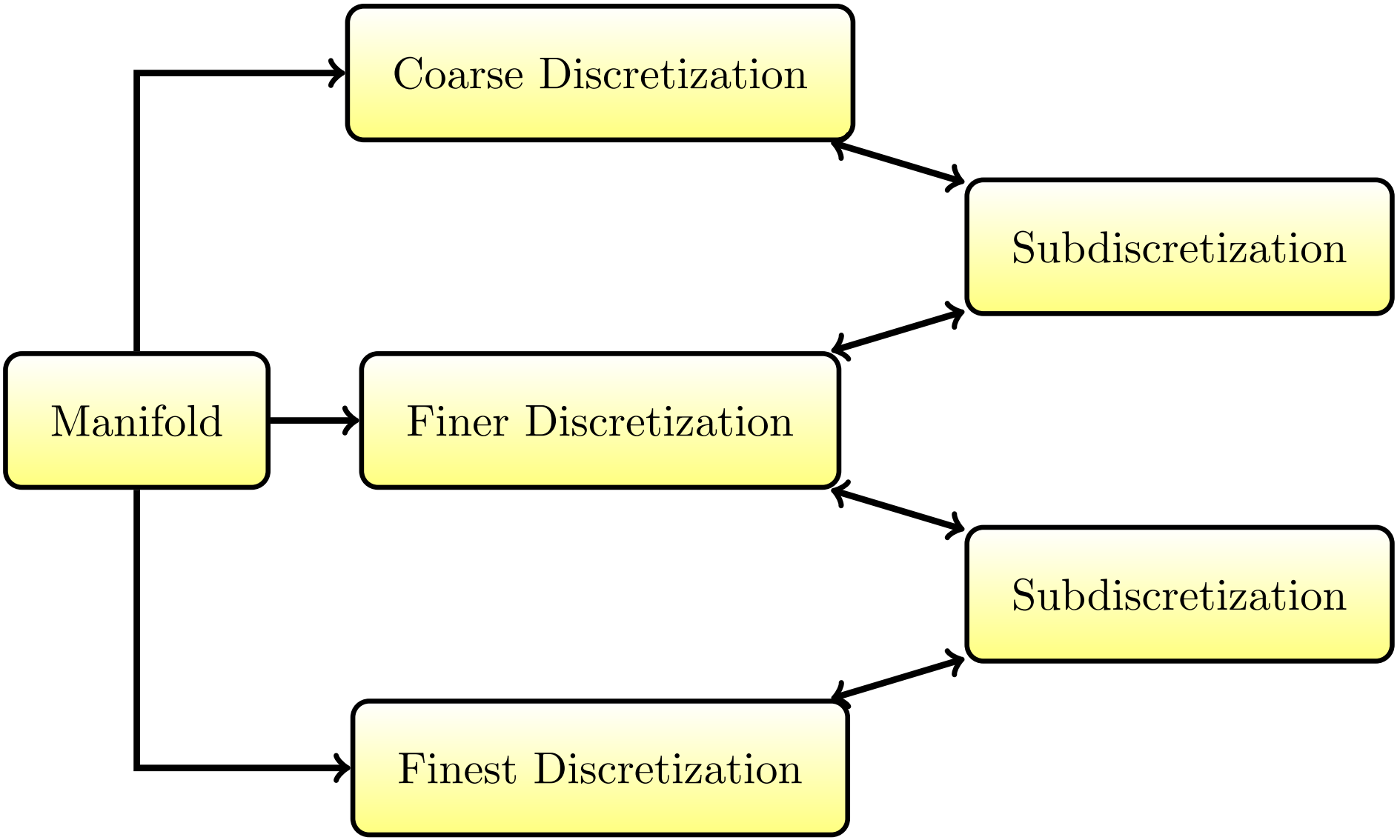
- Fiber Bundle by Werner Benger
- PostCactus by Wolfgang Kastaun
- Simulation Tools by Ian Hinder and Barry Wardell
- scidata by David Radice
- rugutils by Federico Guercilena
- pycactus by Roberto De Pietri, Francesco Maione, and Frank Löffler



Projects as Directed Graphs



AMR in SimulationIO



SimulationIO Utilities

- sio-list is a utility for listing the contents of a file

```
sio-list file.s5
```

- sio-convert-carpet-output converts a sequence of hdf5 files to an s5 file.

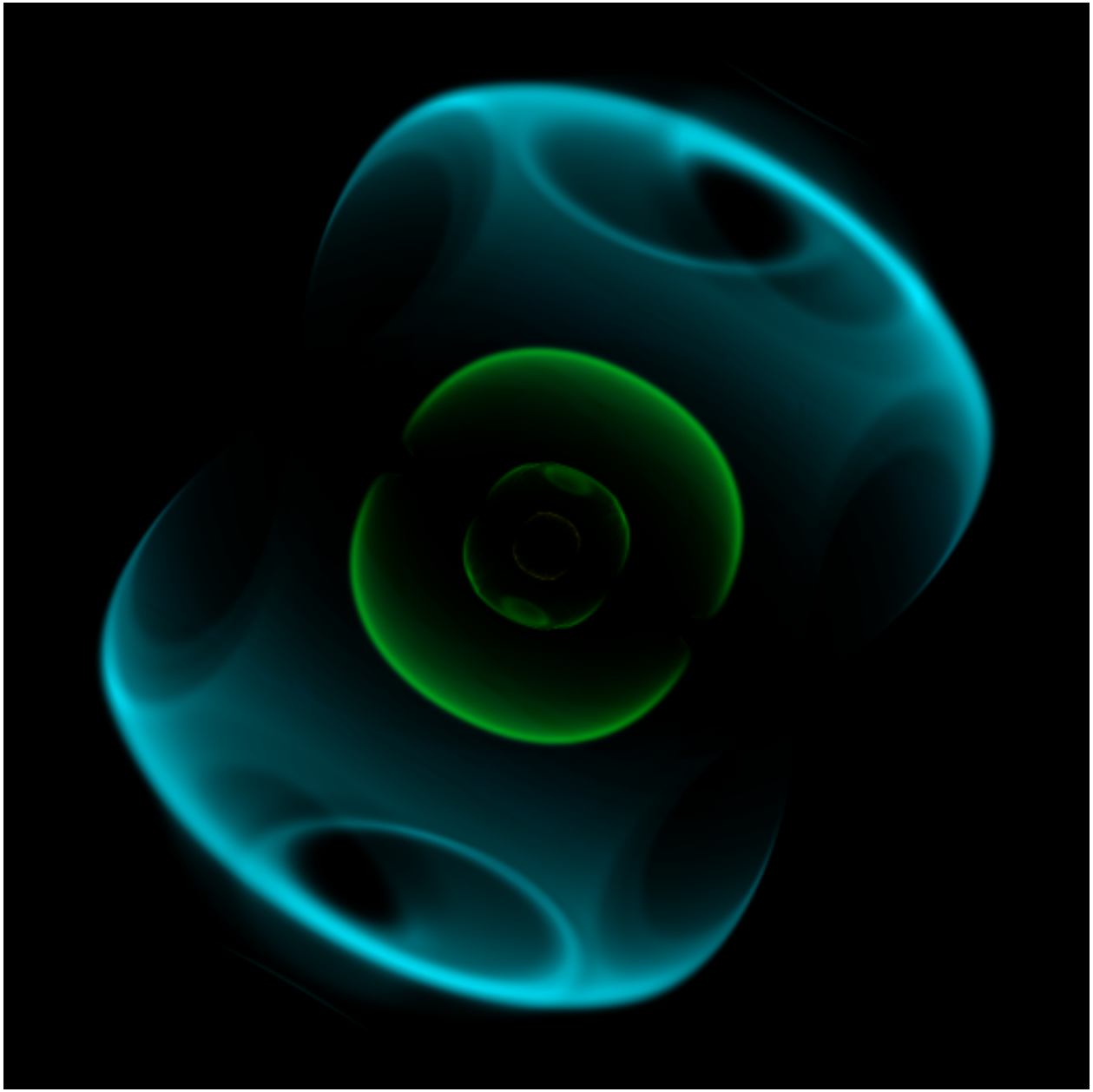
```
sio-convert-carpet-output out.s5 file_*.h5
```

SimulationIO Python API

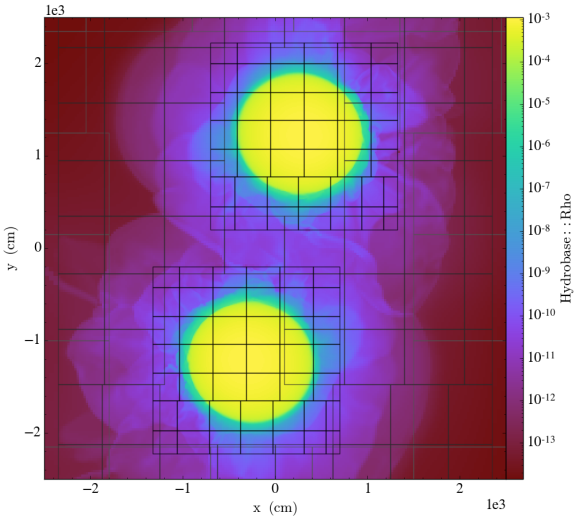
```
import H5
import SimulationIO as SIO
import RegionCalculus as RC
f = H5.H5File(filename,H5.H5F_ACC_RDONLY)
project = SIO.readProject(f)
field = project.fields['rho']
dcf = field.discretefields['rho']
for dcfb in\
dcf.discretefieldblocks.itervalues():
    for dcfbc in\
    dcfb.discretefieldblockcomponents:
        c = dcfbc.values()[0]
        dset = c.getData_DataSet()
        data = np.array(dset.read_double())
```

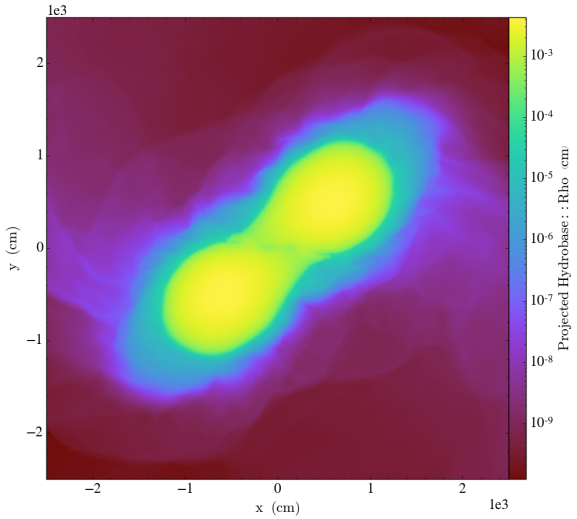
yt

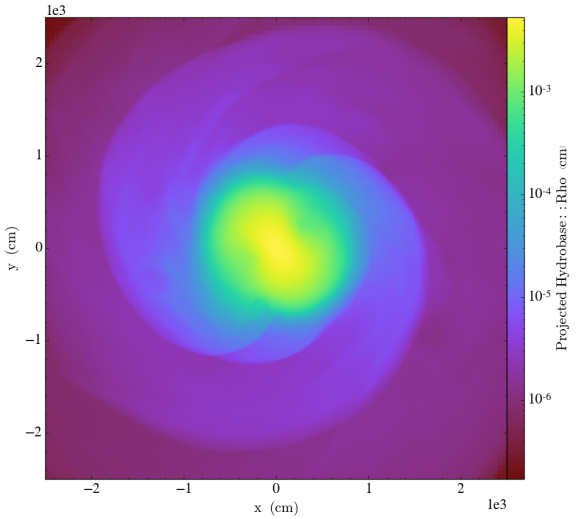
volume rendering



Projections and Slices



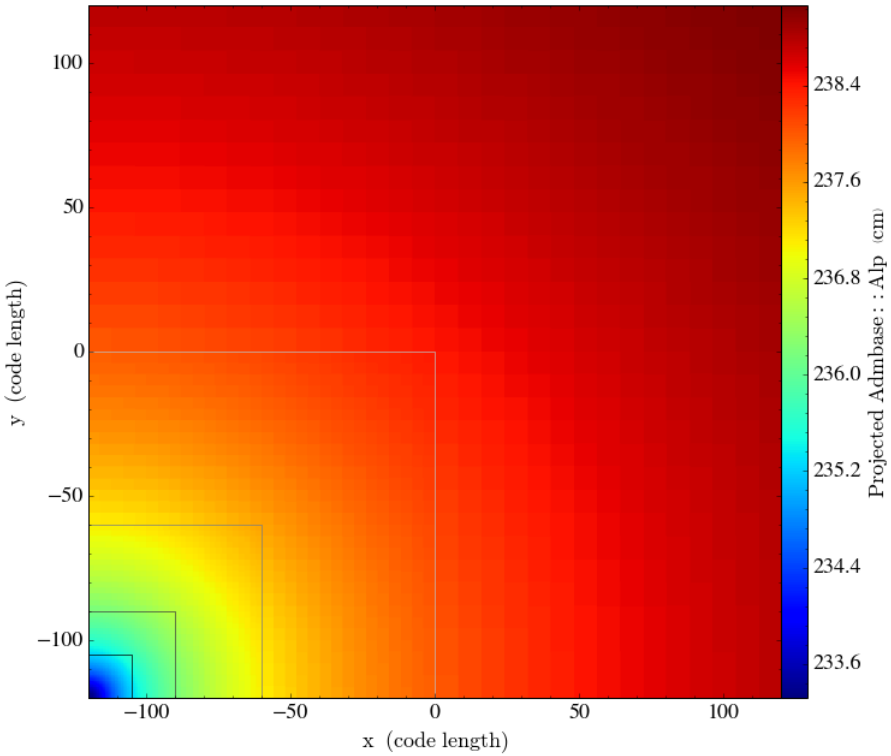




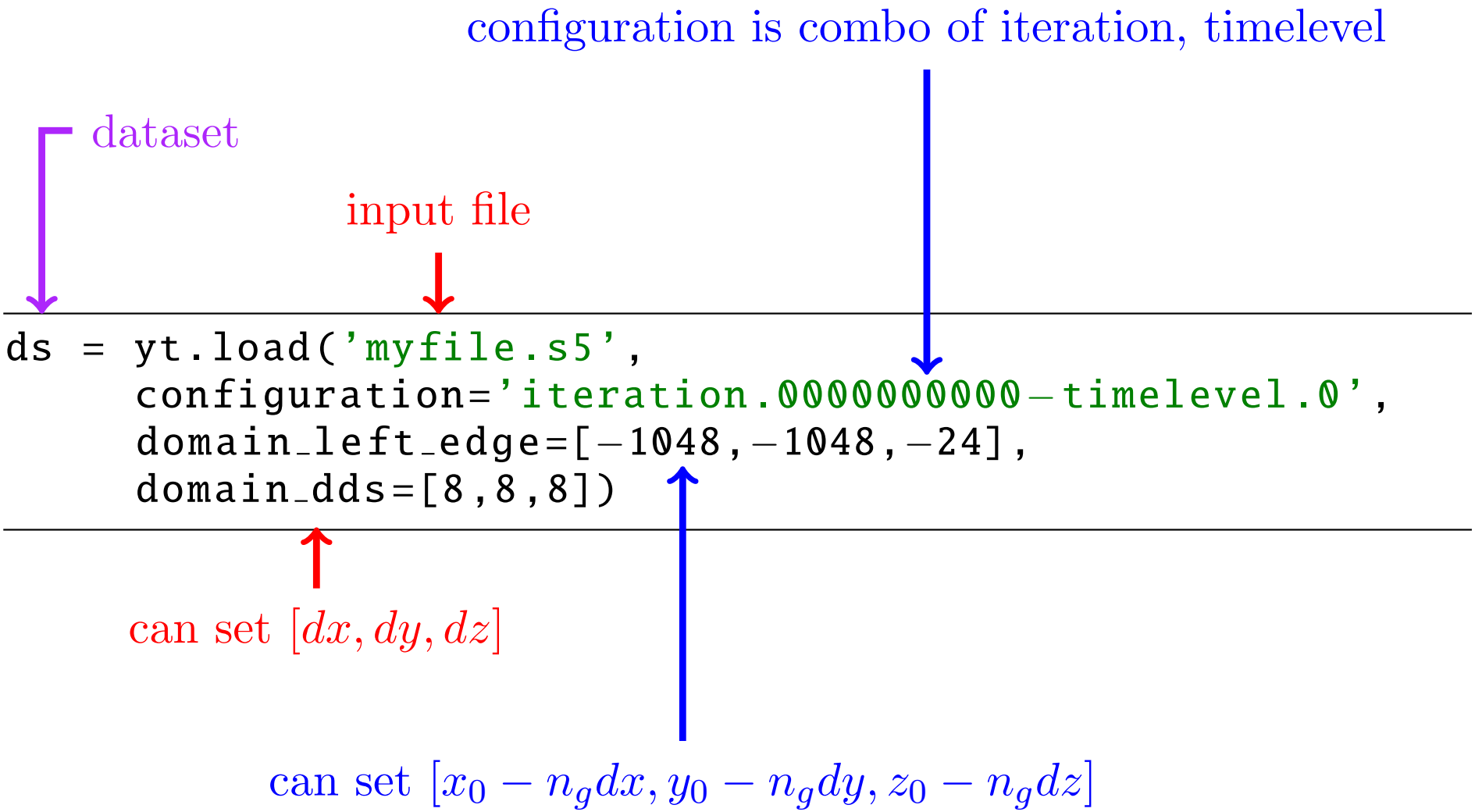
Simulation due to David Radice

Loading SimulationIO Data

```
ds = yt.load(fpath,
    centering='vertex',
    Configuration=conf_name)
p = yt.ProjectionPlot(ds,
    'z','ADMBASE::alp',
    center=center,
    width=width)
p.set_log('ADMBASE::alp',
          False)
p.set_map(field='all',
          cmap='jet')
p.annotate_grids()
p.show()
```



Anatomy of yt.load



Parallelism is Easy

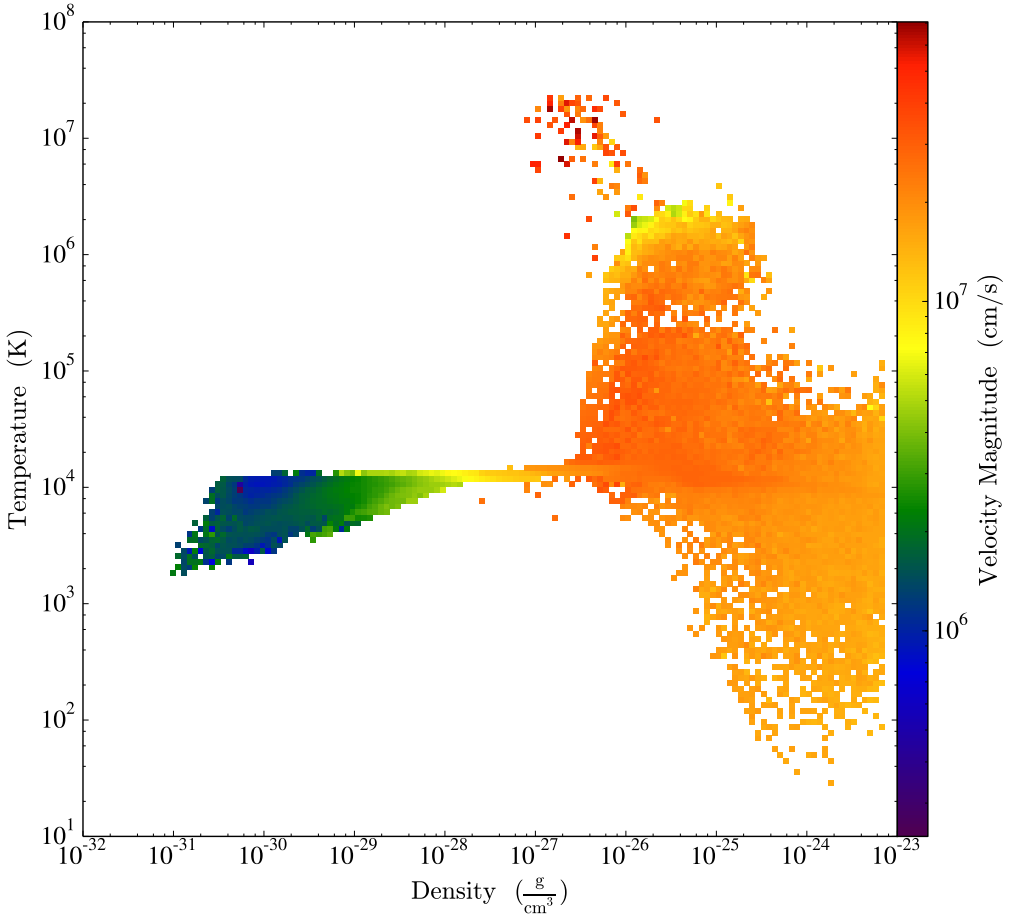
often all you need!

```
import yt
yt.enable_parallelism()
ds = yt.load(fpath,configuration=conf_name)
prj = yt.OffAxisProjectionPlot(ds, orthog_vec,
                               center, width=width)
if yt.is_root():
    prj.save(plot_name)
```

selects root process

Data Analysis

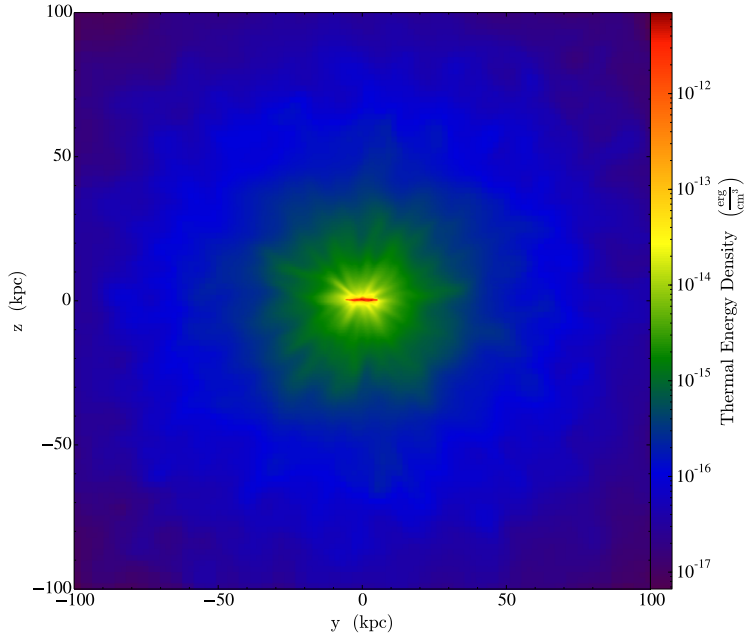
```
import yt
source = "./galaxy0030"
d = "density"
t = "temperature"
vm = "velocty_magnitude"
ds = yt.load(source)
ad = ds.all_data()
yt.PhasePlot(ad,d,t,vm)
```



http://yt-project.org/data/

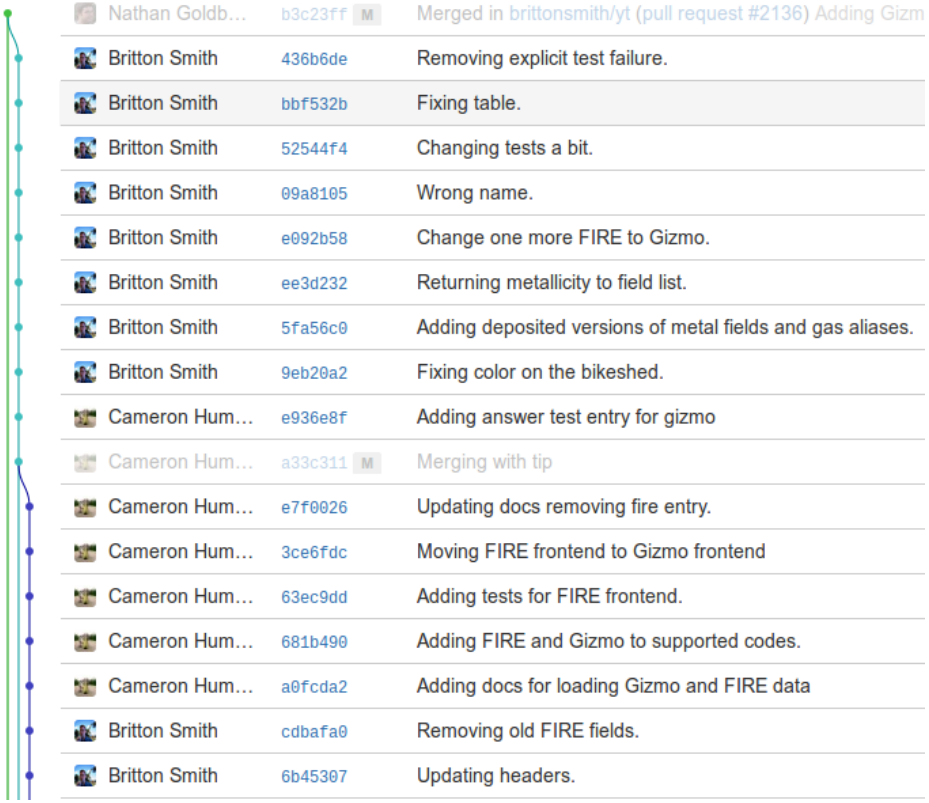
With Python, yt is Easily Extendable

```
# function defining
# new quantity
fname = "thermal_energy_density"
def therm_en_dens(field,data):
    n = data['gas',
             'number_density']
    kT = data['gas', 'kT']
    return (3/2)*n*kT

# add it to the dataset
ds.add_field(("gas",fname),
             units="erg/cm**3",
         function=therm_en_dens)

# plot
ad = ds.all_data()
yt.ProjectionPlot(...)
```



http://yt-project.org/data/

Extensions are Encouraged!



Author	Commit	Message
Nathan Goldb…	b3c23ff M	Merged in brittonsmith/yt (pull request #2136) Adding Gizm
Britton Smith	436b6de	Removing explicit test failure.
Britton Smith	bbf532b	Fixing table.
Britton Smith	52544f4	Changing tests a bit.
Britton Smith	09a8105	Wrong name.
Britton Smith	e092b58	Change one more FIRE to Gizmo.
Britton Smith	ee3d232	Returning metallicity to field list.
Britton Smith	5fa56c0	Adding deposited versions of metal fields and gas aliases.
Britton Smith	9eb20a2	Fixing color on the bikeshed.
Cameron Hum…	e936e8f	Adding answer test entry for gizmo
Cameron Hum…	a33c311 M	Merging with tip
Cameron Hum…	e7f0026	Updating docs removing fire entry.
Cameron Hum…	3ce6fdc	Moving FIRE frontend to Gizmo frontend
Cameron Hum…	63ec9dd	Adding tests for FIRE frontend.
Cameron Hum…	681b490	Adding FIRE and Gizmo to supported codes.
Cameron Hum…	a0fcda2	Adding docs for loading Gizmo and FIRE data
Britton Smith	cdbafa0	Removing old FIRE fields.
Britton Smith	6b45307	Updating headers.

How To Read The Source Code

If you just want to *look* at the source code, you may already have it on your computer. If you build yt using the install script, the source is available at `$YT_DEST/src/yt-hg`. See *Installing yt Using pip or from Source* for more details about to obtain the yt source code if you did not build yt using the install script.

The root directory of the yt mercurial repository contains a number of subdirectories with different components of the code. Most of the yt source code is contained in the yt subdirectory. This directory its self contains the following subdirectories:

`frontends`

This is where interfaces to codes are created. Within each subdirectory of yt/frontends/ there must exist the following files, even if empty:

- `data_structures.py`, where subclasses of AMRGridPatch, Dataset and AMRHierarchy are defined.
- `io.py`, where a subclass of IOHandler is defined.
- `fields.py`, where fields we expect to find in datasets are defined
- `misc.py`, where any miscellaneous functions or classes are defined.
- `definitions.py`, where any definitions specific to the frontend are defined. (i.e., header formats, etc.)

`fields`

This is where all of the derived fields that ship with yt are defined.

`geometry`

This is where geometric helpler routines are defined. Handlers for grid and oct data, as well as

Advantages

- SimulationIO abstracts away simulation details and deals with physics ideas like manifolds and submanifolds
- Both frameworks have a Python API:
  - Scripting interface
  - Easily extendable
- yt is community developed
  - Inclusive and Accessible
- yt parallelizes reliably and seems to scale well

Disadvantages

- No GUI to speak of
- Cactus does not (yet) output SIO files. Must convert.
- SimulationIO and corresponding reader very much in beta
- Missing features:
  - Multiblock
  - Correct Units (coming soon!)
  - Reliable vertex centering

Visualization Tasks

- Gravitational waves from a BBH in-spiral
  - Visualize the ψ_4 at a fixed time and look for the quadrupole moment of the waves in 3D.
  - Visualize the total radiated power at a fixed time.
  - Plot lapse of the black holes at a fixed time.
  - Plot the instantaneous motion of the black holes by overlaying the shift vector
- A single neutron star
  - Experiment with volume plotting the full data
  - Experiment with the vertex-centred symmetric data. What goes wrong when you use cell-centring? What about volume rendering? Plot the grid structure.
- A binary neutron stars
  - Plot the grid structure of the neutron stars at a fixed time
  - Experiment with projections vs. slicing vs. volume plotting. What goes wrong when you make a volume plot?