
ytree Documentation

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`ytree` is a tool for working with merger-tree data from multiple sources. `ytree` is an extension of the `yt` analysis toolkit and provides a similar interface for merger-tree data that includes universal field names, derived fields, and symbolic units. `ytree` is able to load in merger-tree from the following formats:

- `Amiga Halo Finder`
- `Consistent-Trees`
- `LHaloTree`
- `Rockstar` halo catalogs without consistent-trees
- `treefarm`

All formats can be *resaved with a universal format* that can be reloaded with `ytree`. Individual trees for single halos can also be saved.

CHAPTER 1

I want to make merger-trees!

If you have halo catalog data that can be loaded by `yt`, then you can use the `treefarm` package to create merger-trees. `treefarm` was once a part of `ytree`, but is now its own thing.

2.1 Installation

`ytree`'s main dependency is `yt`. Once you have installed `yt` following the instructions [here](#), `ytree` can be installed using `pip`.

```
$ pip install ytree
```

If you'd like to install the development version, the repository can be found at <https://github.com/ytree-project/ytree>. This can be installed by doing:

```
$ git clone https://github.com/ytree-project/ytree
$ cd ytree
$ pip install -e .
```

2.2 What version do I have?

To see what version of `ytree` you are using, do the following:

```
>>> import ytree
>>> print (ytree.__version__)
```

2.3 Sample Data

Sample datasets for every supported data format are available for download from the [yt Hub](#) in the [ytree data](#) collection. The entire collection (about 358 MB) can be downloaded via the `yt` Hub's web interface by clicking on "Actions" dropdown menu on the far right and selecting "Download collection." It can also be downloaded through the `girder-client` interface:

```
$ pip install girder-client
$ girder-cli --api-url https://girder.hub.yt/api/v1 download 59835a1ee2a67400016a2cda_
↪ ytree_data
```

2.4 Working with Merger-Trees

The *Arbor* class is responsible for loading and providing access to merger-tree data. Below, we demonstrate how to load data and what can be done with it.

2.4.1 Loading Merger-Tree Data

ytree can load merger-tree data from multiple sources using the `load` command.

```
>>> import ytree
>>> a = ytree.load("consistent_trees/tree_0_0_0.dat")
```

This command will determine the correct format and read in the data accordingly. For examples of loading each format, see below.

Loading Data

Below are instructions for loading all supported datasets.

Amiga Halo Finder

The *Amiga Halo Finder* format stores data in a series of files, with one each per snapshot. Parameters are stored in “.parameters” and “.log” files, halo information in “.AHF_halos” files, and descendent/ancestor links are stored in “.AHF_mtree” files. Make sure to keep all of these together. To load, provide the name of the first “.parameter” file.

```
>>> import ytree
>>> a = ytree.load("ahf_halos/snap_N64L16_000.parameter",
...               hubble_constant=0.7)
```

Note: Three important notes about loading AHF data:

1. The dimensionless Hubble parameter is not provided in AHF outputs. This should be supplied by hand using the `hubble_constant` keyword. The default value is 1.0.
 2. There will be no “.AHF_mtree” file for index 0 as the “.AHF_mtree” files store links between files N-1 and N.
 3. ytree is able to load data where the graph has been calculated instead of the tree. However, even in this case, only the tree is preserved in ytree. See the [Amiga Halo Finder Documentation](#) for a discussion of the difference between graphs and trees.
-

Consistent-Trees

The *consistent-trees* format is typically one or a few files with a naming convention like “tree_0_0_0.dat”. To load these files, just give the filename

```
>>> import ytree
>>> a = ytree.load("consistent_trees/tree_0_0_0.dat")
```

Rockstar Catalogs

Rockstar catalogs with the naming convention “out_*.list” will contain information on the descendent ID of each halo and can be loaded independently of consistent-trees. This can be useful when your simulation has very few halos, such as in a zoom-in simulation. To load in this format, simply provide the path to one of these files.

```
>>> import ytree
>>> a = ytree.load("rockstar/rockstar_halos/out_0.list")
```

LHaloTree

The **LHaloTree** format is typically one or more files with a naming convention like “trees_063.0” that contain the trees themselves and a single file with a suffix “.a_list” that contains a list of the scale factors at the time of each simulation snapshot.

In addition to the LHaloTree files, ytree also requires additional information about the simulation from a parameter file (in **Gadget** format). At minimum, the parameter file should contain the cosmological parameters `HubbleParam`, `Omega0`, `OmegaLambda`, `BoxSize`, `PeriodicBoundariesOn`, and `ComovingIntegrationOn`, and the unit parameters `UnitVelocity_in_cm_per_s`, `UnitLength_in_cm`, and `UnitMass_in_g`. If not specified explicitly (see below), a file with the extension “.param” will be searched for in the directory containing the LHaloTree files.

If all of the required files are in the same directory, an LHaloTree catalog can be loaded from the path to one of the tree files.

```
>>> import ytree
>>> a = ytree.load("lhalotree/trees_063.0")
```

Both the scale factor and parameter files can be specified explicitly through keyword arguments if they do not match the expected pattern or are located in a different directory than the tree files.

```
>>> a = ytree.load("lhalotree/trees_063.0",
...               parameter_file="lhalotree/param.txt",
...               scale_factor_file="lhalotree/a_list.txt")
```

The scale factors and/or parameters themselves can also be passed explicitly from python.

```
>>> import numpy as np
>>> parameters = dict(HubbleParam=0.7, Omega0=0.3, OmegaLambda=0.7,
...                  BoxSize=62500, PeriodicBoundariesOn=1, ComovingIntegrationOn=1,
...                  UnitVelocity_in_cm_per_s=100000, UnitLength_in_cm=3.08568e21,
...                  UnitMass_in_g=1.989e+43)
>>> scale_factors = [ 0.0078125,  0.012346,  0.019608,  0.032258,  0.047811,
...                  0.051965,  0.056419,  0.061188,  0.066287,  0.071732,
...                  0.07754,   0.083725,  0.090306,  0.097296,  0.104713,
...                  0.112572,  0.120887,  0.129675,  0.13895,   0.148724,
...                  0.159012,  0.169824,  0.181174,  0.19307,   0.205521,
...                  0.218536,  0.232121,  0.24628,   0.261016,  0.27633,
...                  0.292223,  0.308691,  0.32573,   0.343332,  0.361489,
...                  0.380189,  0.399419,  0.419161,  0.439397,  0.460105,
```

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```
...      0.481261 , 0.502839 , 0.524807 , 0.547136 , 0.569789 ,
...      0.59273  , 0.615919 , 0.639314 , 0.66287  , 0.686541 ,
...      0.710278 , 0.734031 , 0.757746 , 0.781371 , 0.804849 ,
...      0.828124 , 0.851138 , 0.873833 , 0.896151 , 0.918031 ,
...      0.939414 , 0.960243 , 0.980457 , 1.         ]
>>> a = ytree.load("lhalotree/trees_063.0",
...                parameters=parameters,
...                scale_factors=scale_factors)
```

TreeFarm

Merger-trees created with `treefarm` can be loaded in by providing the path to one of the catalogs created during the calculation.

```
>>> import ytree
>>> a = ytree.load("tree_farm/tree_farm_descendents/fof_subhalo_tab_000.0.h5")
```

Saved Arbors

Once merger-tree data has been loaded, it can be saved to a universal format using `save_arbor` or `save_tree`. These can be loaded by providing the path to the primary hdf5 file.

```
>>> import ytree
>>> a = ytree.load("arbor/arbor.h5")
```

Saved Arbors from ytree 1.1

Arbors created with version 1.1 of `ytree` and earlier can be reloaded by providing the single file created. It is recommended that arbors be re-saved into the newer format as this will significantly improve performance.

```
>>> import ytree
>>> a = ytree.load("arbor.h5")
```

2.4.2 Working with Merger-Tree Data

Very little happens immediately after a dataset has been loaded. All tree construction and data access occurs only on demand. After loading, information such as the simulation box size, cosmological parameters, and the available fields can be accessed.

```
>>> print (a.box_size)
100.0 Mpc/h
>>> print (a.hubble_constant, a.omega_matter, a.omega_lambda)
0.695 0.285 0.715
>>> print (a.field_list)
['scale', 'id', 'desc_scale', 'desc_id', 'num_prog', ...]
```

Similar to `yt`, `ytree` supports accessing fields by their native names as well as generalized aliases. For more information on fields in `ytree`, see *Fields in ytree*.

How many trees are there?

As soon as any information about the collection of trees within the loaded dataset is requested, an array will be constructed containing objects representing the root of each tree, i.e., the last descendent halo. This structure is accessed by querying the loaded `Arbor` directly. It can also be accessed as `a.trees`.

```
>>> print (a.size)
Loading tree roots: 100%|| 5105985/5105985 [00:00<00:00, 505656111.95it/s]
327
```

Root Fields

Field data for all tree roots is accessed by querying the `Arbor` in a dictionary-like manner.

```
>>> print (a["mass"])
Getting root fields: 100%|| 327/327 [00:00<00:00, 9108.67it/s]
[ 6.57410072e+14  5.28489209e+14  5.18129496e+14  4.88920863e+14, ...,
 8.68489209e+11  8.68489209e+11  8.68489209e+11] Msun
```

ytree uses yt's system for symbolic units, allowing for simple unit conversion.

```
>>> print (a["virial_radius"].to("Mpc/h"))
[ 1.583027  1.471894  1.462154  1.434253  1.354779  1.341322  1.28617, ...,
 0.173696  0.173696  0.173696  0.173696  0.173696] Mpc/h
```

When dealing with cosmological simulations, care must be taken to distinguish between comoving and proper reference frames. Please read [An Important Note on Comoving and Proper Units](#) before your magical ytree journey begins.

Accessing Individual Trees

Individual trees can be accessed by indexing the `Arbor` object.

```
>>> print (a[0])
TreeNode[12900]
```

A `TreeNode` is one halo in a merger-tree. The number is the universal identifier associated with halo. It is unique to the whole arbor. Fields can be accessed for any given `TreeNode` in the same dictionary-like fashion.

```
>>> print (a[0]["mass"])
657410071942446.1 Msun
```

The full lineage of the tree can be accessed by querying any `TreeNode` with the `tree` keyword.

```
>>> my_tree = a[0]
>>> print (my_tree["tree"])
[TreeNode[12900] TreeNode[12539] TreeNode[12166] TreeNode[11796] ...
TreeNode[591]]
```

Fields can be queried for the tree by including the field name.

```
>>> print (my_tree["tree", "virial_radius"])
[ 2277.73669065  2290.65899281  2301.43165468  2311.47625899  2313.99280576 ...,
 434.59856115  410.13381295  411.25755396] kpc
```

A halo’s ancestors are stored as a list in the `ancestors` attribute. The descendants are stored in a similar fashion.

```
>>> print (my_tree.ancestors)
[TreeNode[12539]]
>>> print (my_tree.ancestors[0].descendent)
TreeNode[12900]
```

Accessing the Progenitor Lineage of a Tree

Similar to the *tree* keyword, the *prog* keyword can be used to access the line of main progenitors.

```
>>> print (my_tree["prog"])
[TreeNode[12900] TreeNode[12539] TreeNode[12166] TreeNode[11796] ...
TreeNode[62]]
>>> print (my_tree["prog", "mass"])
[ 6.57410072e+14  6.57410072e+14  6.53956835e+14  6.50071942e+14 ...
 8.29496403e+13  7.72949640e+13  6.81726619e+13  5.99280576e+13] Msun
```

Customizing the Progenitor Line

By default, the progenitor line is defined as the line of the most massive ancestors. This can be changed by calling the *set_selector*.

```
>>> a.set_selector("max_field_value", "virial_radius")
```

New selector functions can also be supplied. These functions should minimally accept a list of ancestors and return a single *TreeNode*.

```
>>> def max_value(ancestors, field):
...     vals = np.array([a[field] for a in ancestors])
...     return ancestors[np.argmax(vals)]
...
>>> ytree.add_tree_node_selector("max_field_value", max_value)
>>>
>>> a.set_selector("max_field_value", "mass")
>>> print (a[0]["prog"])
```

2.4.3 Searching for Halos

The *select_halos* function can be used to search the Arbor for halos matching a specific set of criteria. This is similar to the type of selection done with a relational database.

```
>>> halos = a.select_halos('tree["tree", "redshift"] > 1',
...                       fields=["redshift"])
>>> print (halos)
[TreeNode[8987], TreeNode[6713], TreeNode[6091], TreeNode[448], ...,
TreeNode[9683], TreeNode[8316], TreeNode[10788]]
```

The selection criteria string should be designed to eval correctly with a *TreeNode* object named, “tree”. The *fields* keyword can be used to specify a list of fields to preload for speeding up selection.

2.4.4 Saving Arbors and Trees

Arbors of any type can be saved to a universal file format with the `save_arbor` function. These can be reloaded with the `load` command. This format is optimized for fast tree-building and field-access and so is recommended for most situations.

```
>>> fn = a.save_arbor()
Setting up trees: 100%|| 327/327 [00:00<00:00, 483787.45it/s]
Getting fields [1/1]: 100%|| 327/327 [00:00<00:00, 36704.51it/s]
Creating field arrays [1/1]: 100%|| 613895/613895 [00:00<00:00, 7931878.47it/s]
>>> a2 = ytree.load(fn)
```

By default, all trees and all fields will be saved, but this can be customized with the `trees` and `fields` keywords.

For convenience, individual trees can also be saved by calling `save_tree`.

```
>>> fn = a[0].save_tree()
Creating field arrays [1/1]: 100%|| 4897/4897 [00:00<00:00, 13711286.17it/s]
>>> a2 = ytree.load(fn)
```

2.5 An Important Note on Comoving and Proper Units

Users of `yt` are likely familiar with conversion from proper to comoving reference frames by adding “cm” to a unit. For example, proper “Mpc” becomes comoving with “Mpccm”. This conversion relies on all the data being associated with a single redshift. This is not possible here because the dataset has values for multiple redshifts. To account for this, the proper and comoving unit systems are set to be equal to each other.

```
>>> print (a.box_size)
100.0 Mpc/h
>>> print (a.box_size.to("Mpccm/h"))
100.0 Mpccm/h
```

Data should be assumed to be in the reference frame in which it was saved. For length scales, this is typically the comoving frame. When in doubt, the safest unit to use for lengths is “unitary”, which a system normalized to the box size.

```
>>> print (a.box_size.to("unitary"))
1.0 unitary
```

2.6 Fields in ytree

`ytree` supports multiple types of fields, each representing numerical values associated with each halo in the `Arbor`. These include the *native fields* stored on disk, *alias fields*, *derived fields*, and *analysis fields*.

2.6.1 The Field Info Container

Each `Arbor` contains a dictionary, called `field_info`, with relevant information for each available field. This information can include the units, type of field, any dependencies or aliases, and things relevant to reading the data from disk.

```
>>> import ytree
>>> a = ytree.load("tree_0_0_0.dat")
>>> print (a.field_info["Rvir"])
{'description': 'Halo radius (kpc/h comoving).', 'units': 'kpc/h ', 'column': 11,
 'aliases': ['virial_radius']}
>>> print (a.field_info["mass"])
{'type': 'alias', 'units': 'Msun', 'dependencies': ['Mvir']}
```

2.6.2 Fields on Disk

Every field stored in the dataset's files should be available within the Arbor. The `field_list` contains a list of all fields on disk with their native names.

```
>>> print (a.field_list)
['scale', 'id', 'desc_scale', 'desc_id', 'num_prog', ...]
```

2.6.3 Alias Fields

Because the various dataset formats use different naming conventions for similar fields, ytree allows fields to be referred to by aliases. This allows for a universal set of names for the most common fields. Many are added by default, including “mass”, “virial_radius”, “position_<xyz>”, and “velocity_<xyz>”. The list of available alias and derived fields can be found in the `derived_field_list`.

```
>>> print (a.derived_field_list)
['uid', 'desc_uid', 'scale_factor', 'mass', 'virial_mass', ...]
```

Additional aliases can be added with `add_alias_field`.

```
>>> a.add_alias_field("amount_of_stuff", "mass", units="kg")
>>> print (a["amount_of_stuff"])
[ 1.30720461e+45,  1.05085632e+45,  1.03025691e+45, ...
 1.72691772e+42,  1.72691772e+42,  1.72691772e+42] kg
```

2.6.4 Derived Fields

Derived fields are functions of existing fields, including other derived and alias fields. New derived fields are created by providing a defining function and calling `add_derived_field`.

```
>>> def potential_field(field, data):
...     # data.arbor points to the parent Arbor
...     return data["mass"] / data["virial_radius"]
...
>>> a.add_derived_field("potential", potential_field, units="Msun/Mpc")
[ 2.88624262e+14  2.49542426e+14  2.46280488e+14, ...
 3.47503685e+12  3.47503685e+12  3.47503685e+12] Msun/Mpc
```

Field functions should take two arguments. The first is a dictionary that will contain basic information about the field, such as its name. The second argument represents the data container for which the field will be defined. It can be used to access field data for any other available field. This argument will also have access to the parent Arbor as `data.arbor`.

2.6.5 Vector Fields

For fields that have x, y, and z components, such as position, velocity, and angular momentum, a single field can be queried to return an array with all the components. For example, for fields named “position_x”, “position_y”, and “position_z”, the field “position” will return the full vector.

```
>>> print (a["position"])
[[0.0440018, 0.0672202, 0.9569643],
 [0.7383264, 0.1961563, 0.0238852],
 [0.7042797, 0.6165487, 0.500576 ],
 ...
 [0.1822363, 0.1324423, 0.1722414],
 [0.8649974, 0.4718005, 0.7349876]] unitary
```

A list of defined vector fields can be seen by doing:

```
>>> print (a.field_info.vector_fields)
('position', 'velocity', 'angular_momentum')
```

For all vector fields, a “_magnitude” field also exists, defined as the quadrature sum of the components.

```
>>> print (a["velocity_magnitude"])
[ 488.26936644 121.97143067 146.81450507, ...
 200.74057711 166.13782652 529.7336846 ] km/s
```

2.6.6 Analysis Fields

Analysis fields provide a means for saving the results of complicated analysis for any halo in the `Arbor`. This would be operations beyond derived fields, for example, things that might require loading the original simulation snapshots. New analysis fields are created with `add_analysis_field` and are initialized to zero.

```
>>> a.add_analysis_field("saucer_sections", units="m**2")
>>> print (a[0]["tree", "saucer_sections"])
[ 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.,
 0., 0.,] m**2
>>> import numpy as np
>>> for t in a[0]["tree"]:
...     t["saucer_sections"] = np.random.random() # complicated analysis
...
>>> print (a[0]["tree", "saucer_sections"])
[ 0.33919263 0.79557815 0.38264336 0.53073945 0.09634924 0.6035886, ...
 0.9506636 0.9094426 0.85436984 0.66779632 0.58816873] m**2
```

Analysis fields will be automatically saved when the `Arbor` is saved with `save_arbor`.

2.7 Plotting Merger Trees

Some relatively simple visualizations of merger trees can be made with the `TreePlot` command.

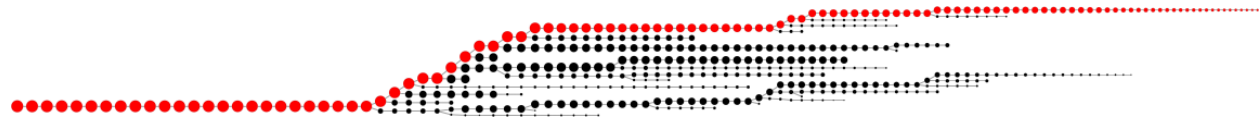
2.7.1 Additional Dependencies

Making merger tree plots with `ytree` requires the `pydot` and `graphviz` packages. `pydot` can be installed with `pip` and the `graphviz` website provides a number of installation options.

2.7.2 Making Tree Plots

The `TreePlot` command can be used to create a `digraph` depicting halos as filled circles with sizes proportional to their mass. The main progenitor line will be colored red.

```
>>> import ytree
>>> a = ytree.load("ahf_halos/snap_N64L16_000.parameter",
...               hubble_constant=0.7)
>>> p = ytree.TreePlot(a[0], dot_kwargs={'rankdir': 'LR', 'size': '"12,4"'})
>>> p.save('tree.png')
```



Plot Modifications

Four `TreePlot` attributes can be set to modify the default plotting behavior. These are:

- `size_field`: The field to determine the size of each circle. Default: 'mass'.
- `size_log`: Whether to scale circle sizes based on log of size field. Default: True.
- `min_mass`: The minimum halo mass to be included in the plot. If given as a float, units are assumed to be Msun. Default: None.
- `min_mass_ratio`: The minimum ratio between a halo's mass and the mass of the main halo to be included in the plot. Default: None.

```
>>> import ytree
>>> a = ytree.load("ahf_halos/snap_N64L16_000.parameter",
...               hubble_constant=0.7)
>>> p = ytree.TreePlot(a[0], dot_kwargs={'rankdir': 'LR', 'size': '"12,4"'})
>>> p.min_mass_ratio = 0.01
>>> p.save('tree_small.png')
```



Supported Output Formats

Plots can be saved to any format supported by `graphviz` by giving a filename with the appropriate extension. See [here](#) for a list of currently supported formats.

2.8 Example Applications

Below are some examples of things one might want to do with merger trees that demonstrate various `ytree` functions. If you have made something interesting, please consider contributing it.

2.8.1 Halo Age

One way to define the age of a halo is by calculating the time when it reached 50% of its current mass. In the example below, this time is calculated by linearly interpolating from the mass of the main progenitor as a function of time.

```
import numpy as np

def t50(tree):
    # main progenitor masses
    pmass = tree['prog', 'mass']

    mh = 0.5 * tree['mass']
    m50 = pmass <= mh

    if not m50.any():
        th = tree['time']
    else:
        ptime = tree['prog', 'time']
        # linearly interpolate
        i = np.where(m50)[0][0]
        slope = (ptime[i-1] - ptime[i]) / (pmass[i-1] - pmass[i])
        th = slope * (mh - pmass[i]) + ptime[i]

    return th
```

Now we'll run it on the first tree in the data set.

```
>>> import ytree
>>> a = ytree.load('consistent_trees/tree_0_0_0.dat')
>>> my_tree = a[0]
>>> print (t50(my_tree).to('Gyr'))
7.2325572094782515 Gyr
```

2.8.2 Significance

Brought to you by John Wise, a halo's significance is calculated by recursively summing over all ancestors the mass multiplied by the time between snapshots. When determining the main progenitor of a halo, the significance measure will select for the ancestor with the deeper history instead of just the higher mass. This can be helpful in cases of near 1:1 mergers.

Below, we define a function that calculates the significance for every halo in a single tree.

```
def get_significance(tree):
    if tree.descendent is None:
        dt = 0. * tree['time']
    else:
        dt = tree.descendent['time'] - tree['time']

    sig = tree['mass'] * dt
    if tree.ancestors is not None:
        for anc in tree.ancestors:
            sig += get_significance(anc)

    tree['significance'] = sig
    return sig
```

We now add a new analysis field to save the significance values for all trees. Then, we will save the arbor with the newly added significance field.

```
>>> import ytree
>>> a = ytree.load('consistent_trees/tree_0_0_0.dat')
>>> a.add_analysis_field('significance', 'Msun*Myr')
>>> for tree in a:
>>>     get_significance(tree)
>>> a.save_arbor('sig_tree')
```

Finally, we can load the new data set and use the significance field to select the main progenitors.

```
>>> import ytree
>>> a = ytree.load('sig_tree/sig_tree.h5')
>>> a.set_selector('max_field_value', 'significance')
>>> print (a[0]['prog'])
[TreeNode[12900] TreeNode[12539] TreeNode[12166] TreeNode[11796] ...
TreeNode[105] TreeNode[62]]
```

2.9 Community Code of Conduct

ytree is a project by members of the [yt community](#). As such, we stand by the [yt Community Code of Conduct](#).

Below is the ytree version of this code.

ytree Community Code of Conduct

The community of participants in open source Scientific projects is made up of members from around the globe with a diverse set of skills, personalities, and experiences. It is through these differences that our community experiences success and continued growth. We expect everyone in our community to follow these guidelines when interacting with others both inside and outside of our community. Our goal is to keep ours a positive, inclusive, successful, and growing community.

As members of the community,

- We pledge to treat all people with respect and provide a harassment- and bullying-free environment, regardless of sex, sexual orientation and/or gender identity, disability, physical appearance, body size, race, nationality, ethnicity, and religion. In particular, sexual language and imagery, sexist, racist, or otherwise exclusionary jokes are not appropriate.
- We pledge to respect the work of others by recognizing acknowledgment/citation requests of original authors. As authors, we pledge to be explicit about how we want our own work to be cited or acknowledged.
- We pledge to welcome those interested in joining the community, and realize that including people with a variety of opinions and backgrounds will only serve to enrich our community. In particular, discussions relating to pros/cons of various technologies, programming languages, and so on are welcome, but these should be done with respect, taking proactive measure to ensure that all participants are heard and feel confident that they can freely express their opinions.
- We pledge to welcome questions and answer them respectfully, paying particular attention to those new to the community. We pledge to provide respectful criticisms and feedback in forums, especially in discussion threads resulting from code contributions.
- We pledge to be conscientious of the perceptions of the wider community and to respond to criticism respectfully. We will strive to model behaviors that encourage productive debate and disagreement, both within our community and where we are criticized. We will treat those outside our community with the same respect as people within our community.

We pledge to help the entire community follow the code of conduct, and to not remain silent when we see violations of the code of conduct. We will take action when members of our community violate this code such as contacting the project manager, Britton Smith (brittonsmith@gmail.com). All emails will be treated with the strictest confidence or talking privately with the person.

This code of conduct applies to all community situations online and offline, including mailing lists, forums, social media, conferences, meetings, associated social events, and one-to-one interactions.

This Community Code of Conduct comes from the [yt Community Code of Conduct](http://yt-project.org/community.html), which was adapted from the [Astropy Community Code of Conduct](http://www.astropy.org/about.html#codeofconduct), which was partially inspired by the PSF code of conduct.

2.10 Contributing to ytree

ytree is a community project and it will be better with your contribution.

Contributions are welcome in the form of code, documentation, or just about anything. If you're interested in getting involved, please do!

ytree is developed using the same conventions as yt. The [yt Developer Guide](#) is a good reference for code style, communication with other developers, working with git, and issuing pull requests. For information specific to ytree, such as testing and adding support for new file formats, see the [ytree Developer Guide](#).

If you'd like to know more, contact Britton Smith (brittonsmith@gmail.com).

You can also find help on the [yt developers list](#).

2.11 Developer Guide

ytree is developed using the same conventions as yt. The [yt Developer Guide](#) is a good reference for code style, communication with other developers, working with git, and issuing pull requests. Below is a brief guide of aspects that are specific to ytree.

2.11.1 Contributing in a Nutshell

Step zero, get out of that nutshell!

After that, the process for making contributions to ytree is roughly as follows:

1. Fork the [main ytree repository](#).
2. Create a new branch.
3. Make changes.
4. Run tests. Return to step 3, if needed.
5. Issue pull request.

The yt Developer Guide and [github](#) documentation will help with the mechanics of git and pull requests.

2.11.2 Testing

The ytree source comes with a series of tests that can be run to ensure nothing unexpected happens after changes have been made. These tests will automatically run when a pull request is issued or updated, but they can also be run locally very easily. At present, the suite of tests for ytree takes about three minutes to run.

Testing Data

The first order of business is to obtain the sample datasets. See [Sample Data](#) for how to do so. Next, `ytree` must be configured to know the location of this data. This is done by creating a configuration file in your home directory at the location `~/.config/ytree/ytreerc`.

```
$ mkdir -p ~/.config/ytree
$ echo [ytree] > ~/.config/ytree/ytreerc
$ echo test_data_dir = /Users/britton/ytree_data >> ~/.config/ytree/ytreerc
$ cat ~/.config/ytree/ytreerc
[ytree]
test_data_dir = /Users/britton/ytree_data
```

This path should point to the outer directory containing all the sample datasets.

Installing Development Dependencies

A number of additional packages are required for testing. These can be installed with `pip` from within the `ytree` source by doing:

```
$ pip install -e .[dev]
```

To see how these dependencies are defined, have a look at the `extras_require` keyword argument in the `setup.py` file.

Run the Tests

The tests are run from the top level of the `ytree` source.

```
$ pytest tests
===== test session starts =====
platform darwin -- Python 3.6.0, pytest-3.0.7, py-1.4.32, pluggy-0.4.0
rootdir: /Users/britton/Documents/work/yt/extensions/ytree/ytree, inifile:
collected 16 items

tests/test_arbors.py .....
tests/test_flake8.py .
tests/test_saving.py ...
tests/test_treefarm.py ..
tests/test_ytree_lx.py ..

===== 16 passed in 185.03 seconds =====
```

2.11.3 Adding Support for a New Format

The `Arbor` class is reasonably generalized such that adding support for a new file format should be relatively straightforward. The existing frontends also provide guidance for what must be done. Below is a brief guide for how to proceed. If you are interested in doing this, we will be more than happy to help!

Where do the files go?

As in `yt`, the code specific to one file format is referred to as a “frontend”. Within the `ytree` source, each frontend is located in its own directory within `ytree/arbor/frontends`. Name your directory using lowercase and

underscores and put it in there.

To allow your frontend to be directly importable at run-time, add the name to the `_frontends` list in `ytree/arbor/frontends/api.py`.

Building Your Frontend

To build a new frontend, you will need to make frontend-specific subclasses for a few components. The easiest way to do this is to start with a blank `Arbor` subclass first. Create a sample script that loads your data with `load`, prints the number of trees, and queries some fields. Within the base classes, the necessary functions will raise a `NotImplementedError` if you have not added them yet. Keep running your script and implementing the function raising this error and before you know it, you'll be done.

The components and the files in which they belong are:

1. The `Arbor` itself (`arbor.py`).
2. The file i/o (`io.py`).
3. Recognizing frontend-specific fields (`fields.py`).

In addition to this, you will need to add a file called `__init__.py`, which will allow your code to be imported. This file should minimally import the frontend-specific `Arbor` class. For example, the `consistent-trees` `__init__.py` looks like this:

```
from ytree.frontends.consistent_trees.arbor import \
    ConsistentTreesArbor
```

Two Types of Arbors

There are generally two types of merger-tree data that `ytree` ingests:

1. all merger-tree data (full trees, halos, etc.) contained within a single file. An example of this is the `consistent-trees` frontend.
2. halos in files grouped by redshift (halo catalogs) that contain the halo id for the descendent halo which lives in the next catalog. An example of this is the `rockstar` frontend.

Depending on your case, different base classes should be subclassed. This is discussed below. There are also hybrid formats that use both merger-tree and halo catalog files together. An example of this is the `ahf` (Amiga Halo Finder) frontend.

The `_is_valid` Function

Within every `Arbor` subclass should appear a function called `_is_valid`. This function is used by `load` to determine if the provide file is the correct type. This function can examine the file's naming convention and/or open it and inspect its contents, whatever is required to uniquely identify your frontend. Have a look at the various examples.

Merger-Tree Data in One File (or a few)

If this is your case, then the `consistent-trees` and “ytree” frontends are the best examples to follow.

In `arbor.py`, your subclass of `Arbor` should implement two functions, `_parse_parameter_file` and `_plant_trees`.

`_parse_parameter_file`: This is the first thing called when your dataset is loaded. It is responsible for determining things like box size, cosmological parameters, and the list of fields.

`_plant_trees`: This function is responsible for constructing the array containing the roots of all trees in the `Arbor`. This should not fully build the trees, but just create `TreeNode` instances for each root and put them in the array.

In `io.py`, you will implement the machinery responsible for reading field data from disk. You must create a subclass of the `TreeFieldIO` class and implement the `_read_fields` function. This function accepts a single root node (a `TreeNode` that is the root of a tree) and a list of fields and should return a dictionary with NumPy arrays for each field.

Halo Catalog-style Data

If this is your case, then the rockstar and treefarm frontends are the best examples to follow.

For this type of data, you will subclass the `CatalogArbor` class, which is itself a subclass of `Arbor` designed for this type of data.

In `arbor.py`, your subclass should implement two functions, `_parse_parameter_file` and `_get_data_files`. The purpose of `_parse_parameter_file` is described above.

`_get_data_files`: This type of data is usually loaded by providing one of the set of files. This function needs to figure out how many other files there are and their names and construct a list to be saved.

In `io.py`, you will create a subclass of `CatalogDataFile` and implement two functions: `_parse_header` and `_read_fields`.

`_parse_header`: This function reads any metadata specific to this halo catalog. For example, you might get the current redshift here.

`_read_fields`: This function is responsible for reading field data from disk. This should minimally take a list of fields and return a dictionary with NumPy arrays for each field for all halos contained in the file. It should also, optionally, take a list of `TreeNode` instances and return fields only for them.

Field Units and Aliases (`fields.py`)

The `FieldInfoContainer` class holds information about field names and units. Your subclass can define two tuples, `known_fields` and `alias_fields`. The `known_fields` tuple is used to set units for fields on disk. This is useful especially if there is no way to get this information from the file. The convention for each entry is (name on disk, units).

By creating aliases to standardized names, scripts can be run on multiple types of data with little or no alteration for frontend-specific field names. This is done with the `alias_fields` tuple. The convention for each entry is (alias name, name on disk, field units).

```
from ytree.data_structures.fields import \
    FieldInfoContainer

class NewCodeFieldInfo(FieldInfoContainer):
    known_fields = (
        # name on disk, units
        ("Mass", "Msun/h"),
        ("PX", "kpc/h"),
    )

    alias_fields = (
        # alias name, name on disk, units for alias
```

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(continued from previous page)

```

    ("mass", "Mass", "Msun"),
    ("position_x", "PX", "Mpc/h"),
    ...
)

```

You made it!

That's all there is to it! Now you too can do whatever it is people do with merger-trees. There are probably important things that were left out of this document. If you find any, please consider making an addition or opening an issue. If you're stuck anywhere, don't hesitate to ask for help. If you've gotten this far, we really want to see you make it to the finish!

Everyone Loves Samples

It would be especially great if you could provide a small sample dataset with your new frontend, something less than a few hundred MB if possible. This will ensure that your new frontend never gets broken and will also help new users get started. Once you have some data, make an addition to the arbor tests by following the example in `tests/test_arbors.py`. Then, contact Britton Smith to arrange for your sample data to be added to the [ytree data](#) collection on the [yt Hub](#).

Ok, now you're totally done. Take the rest of the afternoon off.

2.12 Help

If you encounter problems, we want to help and there are lots of places to get help. As an extension of the [yt project](#), we are members of the yt community. Any questions regarding `ytree` can be posted to the [yt users list](#). You will also find interactive help on the [yt slack channel](#).

Bugs and feature requests can also be posted on the [ytree issues page](#).

See you out there!

2.13 Citing ytree

If you use ytree in your work, please cite the following:

Britton Smith, & Meagan Lang. (2018, February 16). ytree: merger-tree toolkit. Zenodo. <http://doi.org/10.5281/zenodo.1174374>

For BibTeX users:

```

@misc{britton_smith_2018_1174374,
  author      = {Britton Smith and
                 Meagan Lang},
  title       = {ytree: merger-tree toolkit},
  month       = feb,
  year        = 2018,
  doi         = {10.5281/zenodo.1174374},
  url         = {https://doi.org/10.5281/zenodo.1174374}
}

```

If possible, please also add a footnote pointing to <http://ytree.readthedocs.io>.

2.14 Reference

Below are some reference materials for `ytree`, including API documentation for all available functionality and a log of changes from each stable release.

2.14.1 API Reference

Working with Merger Trees

The `load` can load all supported merger tree formats. Once loaded, the `save_arbor` and `save_tree` functions can be used to save the entire arbor or individual trees.

| | |
|--|--|
| <code>load(filename[, method])</code> | Load an Arbor, determine the type automatically. |
| <code>Arbor(filename)</code> | Base class for all Arbor classes. |
| <code>add_alias_field(alias, field[, units, force_add])</code> | Add a field as an alias to another field. |
| <code>add_analysis_field(name, units)</code> | Add an empty field to be filled by analysis operations. |
| <code>add_derived_field(name, function[, units, ...])</code> | Add a field that is a function of other fields. |
| <code>save_arbor([filename, fields, trees, ...])</code> | Save the arbor to a file. |
| <code>select_halos(criteria[, trees, select_from, ...])</code> | Select halos from the arbor based on a set of criteria given as a string. |
| <code>save_tree([filename, fields])</code> | Save the tree to a file. |
| <code>set_selector(selector, *args, **kwargs)</code> | Sets the tree node selector to be used. |
| <code>TreeNodeSelector(function[, args, kwargs])</code> | The <code>TreeNodeSelector</code> is responsible for choosing which one of a halo's ancestors to return when querying the line of main progenitors for a halo. |
| <code>add_tree_node_selector(name, function)</code> | Add a <code>TreeNodeSelector</code> to the registry of known selectors, so they can be chosen with <code>set_selector</code> . |
| <code>max_field_value(ancestors, field)</code> | Return the <code>TreeNode</code> with the maximum value of the given field. |
| <code>min_field_value(ancestors, field)</code> | Return the <code>TreeNode</code> with the minimum value of the given field. |

`ytree.data_structures.arbor.load`

`ytree.data_structures.arbor.load(filename, method=None, **kwargs)`

Load an Arbor, determine the type automatically.

Parameters

- **filename** (*string*) – Input filename.
- **method** (*optional, string*) – The type of Arbor to be loaded. Existing types are: `ConsistentTrees`, `Rockstar`, `TreeFarm`, `YTree`. If not given, the type will be determined based on characteristics of the input file.
- **kwargs** (*optional, dict*) – Additional keyword arguments are passed to `_is_valid` and the determined type.

Returns

Return type *Arbor*

Examples

```
>>> import ytree
>>> # saved Arbor
>>> a = ytree.load("arbor/arbor.h5")
>>> # consistent-trees output
>>> a = ytree.load("rockstar_halos/trees/tree_0_0_0.dat")
>>> # Rockstar catalogs
>>> a = ytree.load("rockstar_halos/out_0.list")
>>> # TreeFarm catalogs
>>> a = ytree.load("my_halos/fof_subhalo_tab_025.0.h5")
>>> # LHaloTree catalogs
>>> a = ytree.load("my_halos/trees_063.0")
>>> # Amiga Halo Finder
>>> a = ytree.load("ahf_halos/snap_N64L16_000.parameter",
...               hubble_constant=0.7)
```

ytree.data_structures.arbor.Arbor

class ytree.data_structures.arbor.**Arbor** (*filename*)

Base class for all Arbor classes.

Loads a merger-tree output file or a series of halo catalogs and create trees, stored in an array in `trees`. Arbors can be saved in a universal format with `save_arbor`. Also, provide some convenience functions for creating YTArrays and YTQuantities and a cosmology calculator.

__init__ (*filename*)

Initialize an Arbor given an input file.

Methods

| | |
|--|--|
| <code>__init__(filename)</code> | Initialize an Arbor given an input file. |
| <code>add_alias_field(alias, field[, units, force_add])</code> | Add a field as an alias to another field. |
| <code>add_analysis_field(name, units)</code> | Add an empty field to be filled by analysis operations. |
| <code>add_derived_field(name, function[, units, ...])</code> | Add a field that is a function of other fields. |
| <code>is_grown(tree_node)</code> | Return True if a tree has been fully assembled, i.e., the hierarchy of ancestor tree nodes has been built. |
| <code>is_setup(tree_node)</code> | Return True if arrays of uids and descendent uids have been read in. |
| <code>query(key)</code> | If given a string, return an array of field values for the roots of all trees. |
| <code>save_arbor([filename, fields, trees, ...])</code> | Save the arbor to a file. |
| <code>select_halos(criteria[, trees, select_from, ...])</code> | Select halos from the arbor based on a set of criteria given as a string. |
| <code>set_selector(selector, *args, **kwargs)</code> | Sets the tree node selector to be used. |

Attributes

| | |
|------------------------------|---|
| <code>arr</code> | Create a YTArray using the Arbor's unit registry. |
| <code>box_size</code> | The simulation box size. |
| <code>field_info</code> | A dictionary containing information for each available field. |
| <code>hubble_constant</code> | Value of the Hubble parameter. |
| <code>quan</code> | Create a YTQuantity using the Arbor's unit registry. |
| <code>size</code> | Return length of tree list. |
| <code>trees</code> | Array containing all trees in the arbor. |
| <code>unit_registry</code> | Unit system registry. |

`ytree.data_structures.arbor.Arbor.add_alias_field`

`Arbor.add_alias_field(alias, field, units=None, force_add=True)`

Add a field as an alias to another field.

Parameters

- **alias** (*string*) – Alias name.
- **field** (*string*) – The field to be aliased.
- **units** (*optional, string*) – Units in which the field will be returned.
- **force_add** (*optional, bool*) – If True, add field even if it already exists and warn the user and raise an exception if dependencies do not exist. If False, silently do nothing in both instances. Default: True.

Examples

```
>>> import ytree
>>> a = ytree.load("tree_0_0_0.dat")
>>> # "Mvir" exists on disk
>>> a.add_alias_field("mass", "Mvir", units="Msun")
>>> print (a["mass"])
```

`ytree.data_structures.arbor.Arbor.add_analysis_field`

`Arbor.add_analysis_field(name, units)`

Add an empty field to be filled by analysis operations.

Parameters

- **name** (*string*) – Field name.
- **units** (*string*) – Field units.

Examples

```
>>> import ytree
>>> a = ytree.load("tree_0_0_0.dat")
>>> a.add_analysis_field("robots", "Msun * kpc")
>>> # Set field for some halo.
>>> a[0]["tree"][7]["robots"] = 1979.816
```

ytree.data_structures.arbor.Arbor.add_derived_field

`Arbor.add_derived_field(name, function, units=None, description=None, vector_field=False, force_add=True)`

Add a field that is a function of other fields.

Parameters

- **name** (*string*) – Field name.
- **function** (*callable*) – The function to be called to generate the field. This function should take two arguments, the arbor and the data structure containing the dependent fields. See below for an example.
- **units** (*optional, string*) – The units in which the field will be returned.
- **description** (*optional, string*) – A short description of the field.
- **vector_field** (*optional, bool*) – If True, field is an xyz vector. Default: False.
- **force_add** (*optional, bool*) – If True, add field even if it already exists and warn the user and raise an exception if dependencies do not exist. If False, silently do nothing in both instances. Default: True.

Examples

```
>>> import ytree
>>> a = ytree.load("tree_0_0_0.dat")
>>> def _redshift(field, data):
...     return 1. / data["scale"] - 1
...
>>> a.add_derived_field("redshift", _redshift)
>>> print (a["redshift"])
```

ytree.data_structures.arbor.Arbor.save_arbor

`Arbor.save_arbor(filename='arbor', fields=None, trees=None, max_file_size=524288)`

Save the arbor to a file.

The saved arbor can be re-loaded as an arbor.

Parameters

- **filename** (*optional, string*) – Output file keyword. If filename ends in “.h5”, the main header file will be just that. If not, filename will be <filename>/<basename>.h5. Default: “arbor”.
- **fields** (*optional, list of strings*) – The fields to be saved. If not given, all fields will be saved.

Returns `header_filename` – The filename of the saved arbor.

Return type string

Examples

```
>>> import ytree
>>> a = ytree.load("rockstar_halos/trees/tree_0_0_0.dat")
>>> fn = a.save_arbor()
>>> # reload it
>>> a2 = ytree.load(fn)
```

ytree.data_structures.arbor.Arbor.select_halos

`Arbor.select_halos(criteria, trees=None, select_from='tree', fields=None)`

Select halos from the arbor based on a set of criteria given as a string.

Parameters

- **criteria** (*string*) – A string that will eval to a Numpy-like selection operation performed on a `TreeNode` object called “tree”. Example: `‘tree[“tree”, “redshift”] > 1’`
- **trees** (*optional, list or array of TreeNodes*) – A list or array of `TreeNode` objects in which to search. If none given, the search is performed over the full arbor.
- **select_from** (*optional, “tree” or “prog”*) – Determines whether to perform the search over the full tree or just the main progenitors. Note, the value given must be consistent with what appears in the criteria string. For example, a criteria string of `‘tree[“tree”, “redshift”] > 1’` cannot be used when setting `select_from` to “prog”. Default: “tree”.
- **fields** (*optional, list of strings*) – Use to provide a list of fields required by the criteria evaluation. If given, fields will be preloaded in an optimized way and the search will go faster. Default: None.

Returns halos – A flat array of all `TreeNode`s meeting the criteria.

Return type array of `TreeNode`s

Examples

```
>>> import ytree
>>> a = ytree.load("tree_0_0_0.dat")
>>> halos = a.select_halos('tree["tree", "redshift"] > 1',
...                       fields=["redshift"])
>>>
>>> halos = a.select_halos('tree["prog", "mass"].to("Msun") >= 1e10',
...                       select_from="prog", fields=["mass"])
```

ytree.data_structures.tree_node.TreeNode.save_tree

`TreeNode.save_tree(filename=None, fields=None)`

Save the tree to a file.

The saved tree can be re-loaded as an arbor.

Parameters

- **filename** (*optional, string*) – Output file keyword. Main header file will be named <filename>/<filename>.h5. Default: “tree_<uid>”.
- **fields** (*optional, list of strings*) – The fields to be saved. If not given, all fields will be saved.

Returns filename – The filename of the saved arbor.

Return type string

Examples

```
>>> import ytree
>>> a = ytree.load("rockstar_halos/trees/tree_0_0_0.dat")
>>> # save the first tree
>>> fn = a[0].save_tree()
>>> # reload it
>>> a2 = ytree.load(fn)
```

ytree.data_structures.arbor.Arbor.set_selector

Arbor.**set_selector** (*selector, *args, **kwargs*)

Sets the tree node selector to be used.

This sets the manner in which halo progenitors are chosen from a list of ancestors. The most obvious example is to select the most massive ancestor.

Parameters

- **selector** (*string*) – Name of the selector to be used.
- **additional arguments and keywords to be provided to** (*Any*) –
- **selector function should follow.** (*the*) –

Examples

```
>>> import ytree
>>> a = ytree.load("rockstar_halos/trees/tree_0_0_0.dat")
>>> a.set_selector("max_field_value", "mass")
```

ytree.data_structures.tree_node_selector.TreeNodeSelector

class ytree.data_structures.tree_node_selector.**TreeNodeSelector** (*function,*
args=None,
kwargs=None)

The **TreeNodeSelector** is responsible for choosing which one of a halo’s ancestors to return when querying the line of main progenitors for a halo.

Parameters

- **ancestors** (*list of TreeNode objects*) – List of **TreeNode** objects from which to select.
- **function should return a single TreeNode.** (*The*) –

Examples

```
>>> import ytree
>>> def max_value(ancestors, field):
...     vals = np.array([a[field] for a in ancestors])
...     return ancestors[np.argmax(vals)]
>>> ytree.add_tree_node_selector("max_field_value", max_value)
>>> a = ytree.load("tree_0_0_0.dat")
>>> a.set_selector("max_field_value", "mass")
>>> print (a[0]["prog"])
```

__init__ (function, args=None, kwargs=None)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|------------------|
| __init__ (function[, args, kwargs]) | Initialize self. |
|--|------------------|

ytree.data_structures.tree_node_selector.add_tree_node_selector

ytree.data_structures.tree_node_selector.**add_tree_node_selector** (name, function)
Add a TreeNodeSelector to the registry of known selectors, so they can be chosen with *set_selector*.

Parameters

- **name** (*string*) – Name of the selector.
- **function** (*callable*) – The associated function.

Examples

```
>>> import ytree
>>> def max_value(ancestors, field):
...     vals = np.array([a[field] for a in ancestors])
...     return ancestors[np.argmax(vals)]
>>> ytree.add_tree_node_selector("max_field_value", max_value)
>>> a = ytree.load("tree_0_0_0.dat")
>>> a.set_selector("max_field_value", "mass")
>>> print (a[0]["prog"])
```

ytree.data_structures.tree_node_selector.max_field_value

ytree.data_structures.tree_node_selector.**max_field_value** (ancestors, field)
Return the TreeNode with the maximum value of the given field.

Parameters

- **ancestors** (*list of TreeNode objects*) – List of TreeNode objects from which to select.
- **field** (*string*) – Field to be used for selection.

Returns

Return type `TreeNode` object

`ytree.data_structures.tree_node_selector.min_field_value`

`ytree.data_structures.tree_node_selector.min_field_value(ancestors, field)`

Return the `TreeNode` with the minimum value of the given field.

Parameters

- **ancestors** (*list of `TreeNode` objects*) – List of `TreeNode` objects from which to select.
- **field** (*string*) – Field to be used for selection.

Returns

Return type `TreeNode` object

Visualizing Merger Trees

Functionality for plotting merger trees.

| | |
|---|--|
| <code>TreePlot(tree[, dot_kwargs])</code> | Make a simple merger tree plot using pydot and graphviz. |
| <code>save([filename])</code> | Save the merger tree plot. |

`ytree.visualization.tree_plot.TreePlot`

class `ytree.visualization.tree_plot.TreePlot(tree, dot_kwargs=None)`

Make a simple merger tree plot using pydot and graphviz.

Parameters

- **tree** (merger tree node `TreeNode`) – The merger tree to be plotted.
- **dot_kwargs** (*optional, dict*) – A dictionary of keyword arguments to be passed to `pydot.Dot`. Default: `None`.

size_field

The field to determine the size of each circle. Default: `'mass'`.

Type `str`

size_log

Whether to scale circle sizes based on log of size field. Default: `True`.

Type `bool`

min_mass

The minimum halo mass to be included in the plot. If given as a float, units are assumed to be `Msun`. Default: `None`.

Type float or `YTQuantity`

min_mass_ratio

The minimum ratio between a halo's mass and the mass of the main halo to be included in the plot. Default: `None`.

Type float

Examples

```
>>> import ytree
>>> a = ytree.load("tree_0_0_0.dat")
>>> p = ytree.TreePlot(a[0])
>>> p.min_mass = 1e6 # Msun
>>> p.save()
```

`__init__(tree, dot_kwargs=None)`
Initialize a TreePlot.

Methods

| | |
|---|----------------------------|
| <code>__init__(tree[, dot_kwargs])</code> | Initialize a TreePlot. |
| <code>save([filename])</code> | Save the merger tree plot. |

Attributes

| | |
|-----------------------------|---|
| <code>min_mass</code> | The minimum halo mass to be included in the plot. |
| <code>min_mass_ratio</code> | The minimum halo mass to main halo mass. |
| <code>size_field</code> | The field to determine the size of each circle. |
| <code>size_log</code> | Whether to scale circle sizes based on log of size field. |

ytree.visualization.tree_plot.TreePlot.save

`TreePlot.save(filename=None)`
Save the merger tree plot.

Parameters `filename` (*optional, str*) – The output filename. If none given, the uid of the head node is used. Default: None.

Examples

```
>>> import ytree
>>> a = ytree.load("tree_0_0_0.dat")
>>> p = ytree.TreePlot(a[0])
>>> p.save('tree.png')
```

Internal Classes

| | |
|-------------------------------------|--|
| <code>Arbor(filename)</code> | Base class for all Arbor classes. |
| <code>CatalogArbor(filename)</code> | Base class for Arbors created from a series of halo catalog files where the descendent ID for each halo has been pre-determined. |

Continued on next page

Table 8 – continued from previous page

| | |
|--|--|
| <i>FieldInfoContainer</i> (arbor) | A container for information about fields. |
| <i>FieldContainer</i> (arbor) | A container for field data. |
| <i>FakeFieldContainer</i> (arbor[, name]) | A fake field data container used to calculate dependencies. |
| <i>FieldIO</i> (arbor) | Base class for FieldIO classes. |
| <i>TreeFieldIO</i> (arbor) | IO class for getting fields for a tree. |
| <i>DefaultRootFieldIO</i> (arbor) | Class for getting root fields from arbors that have no specialized storage for root fields. |
| <i>DataFile</i> (filename) | Base class for data files. |
| <i>CatalogDataFile</i> (filename, arbor) | Base class for halo catalog files. |
| <i>TreeNode</i> (uid[, arbor, root]) | Class for objects stored in Arbors. |
| <i>TreeNodeSelector</i> (function[, args, kwargs]) | The <i>TreeNodeSelector</i> is responsible for choosing which one of a halo's ancestors to return when querying the line of main progenitors for a halo. |
| <i>AHFArbor</i> (filename[, hubble_constant]) | Arbor for Amiga Halo Finder data. |
| <i>AHFFieldInfo</i> (arbor) | |
| <i>AHFDataFile</i> (filename, arbor) | |
| <i>ArborArbor</i> (filename) | Class for Arbors created with ytree version 1.1.0 or earlier. |
| <i>ArborArborFieldInfo</i> (arbor) | |
| <i>ArborArborTreeFieldIO</i> (arbor) | |
| <i>ArborArborRootFieldIO</i> (arbor) | |
| <i>ConsistentTreesArbor</i> (filename) | Arbors from consistent-trees output files. |
| <i>ConsistentTreesFieldInfo</i> (arbor) | |
| <i>ConsistentTreesDataFile</i> (filename) | |
| <i>ConsistentTreesTreeFieldIO</i> (arbor) | |
| <i>LHaloTreeArbor</i> (*args, **kwargs) | Arbors for LHaloTree data. |
| <i>LHaloTreeFieldInfo</i> (arbor) | |
| <i>LHaloTreeTreeFieldIO</i> (arbor) | |
| <i>LHaloTreeRootFieldIO</i> (arbor) | |
| <i>RockstarArbor</i> (filename) | Class for Arbors created from Rockstar out_*.list files. |
| <i>RockstarFieldInfo</i> (arbor) | |
| <i>RockstarDataFile</i> (filename, arbor) | |
| <i>TreeFarmArbor</i> (filename) | Class for Arbors created with TreeFarm. |
| <i>TreeFarmFieldInfo</i> (arbor) | |
| <i>TreeFarmDataFile</i> (filename, arbor) | |
| <i>TreeFarmTreeFieldIO</i> (arbor) | |
| <i>YTreeArbor</i> (filename) | Class for Arbors created from the <i>save_arbor</i> or <i>save_tree</i> functions. |
| <i>YTreeDataFile</i> (filename) | |
| <i>YTreeTreeFieldIO</i> (arbor) | |
| <i>YTreeRootFieldIO</i> (arbor) | |

ytree.data_structures.arbor.CatalogArbor

class ytree.data_structures.arbor.CatalogArbor (*filename*)

Base class for Arbors created from a series of halo catalog files where the descendent ID for each halo has been pre-determined.

__init__ (*filename*)

Initialize an Arbor given an input file.

Methods

| | |
|--|--|
| <code>__init__(filename)</code> | Initialize an Arbor given an input file. |
| <code>add_alias_field(alias, field[, units, force_add])</code> | Add a field as an alias to another field. |
| <code>add_analysis_field(name, units)</code> | Add an empty field to be filled by analysis operations. |
| <code>add_derived_field(name, function[, units, ...])</code> | Add a field that is a function of other fields. |
| <code>is_grown(tree_node)</code> | Return True if a tree has been fully assembled, i.e., the hierarchy of ancestor tree nodes has been built. |
| <code>is_setup(tree_node)</code> | Return True if arrays of uids and descendent uids have been read in. |
| <code>query(key)</code> | If given a string, return an array of field values for the roots of all trees. |
| <code>save_arbor([filename, fields, trees, ...])</code> | Save the arbor to a file. |
| <code>select_halos(criteria[, trees, select_from, ...])</code> | Select halos from the arbor based on a set of criteria given as a string. |
| <code>set_selector(selector, *args, **kwargs)</code> | Sets the tree node selector to be used. |

Attributes

| | |
|------------------------------|---|
| <code>arr</code> | Create a YTArray using the Arbor's unit registry. |
| <code>box_size</code> | The simulation box size. |
| <code>field_info</code> | A dictionary containing information for each available field. |
| <code>hubble_constant</code> | Value of the Hubble parameter. |
| <code>quan</code> | Create a YTQuantity using the Arbor's unit registry. |
| <code>size</code> | Return length of tree list. |
| <code>trees</code> | Array containing all trees in the arbor. |
| <code>unit_registry</code> | Unit system registry. |

ytree.data_structures.fields.FieldInfoContainer

class `ytree.data_structures.fields.FieldInfoContainer` (*arbor*)

A container for information about fields.

`__init__` (*arbor*)

Initialize self. See `help(type(self))` for accurate signature.

Methods

| | |
|------------------------------|--|
| <code>__init__(arbor)</code> | Initialize self. |
| <code>clear()</code> | |
| <code>copy()</code> | |
| <code>fromkeys</code> | Create a new dictionary with keys from iterable and values set to value. |
| <code>get</code> | Return the value for key if key is in the dictionary, else default. |

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| | |
|--|---|
| <code>items()</code> | |
| <code>keys()</code> | |
| <code>pop(k[,d])</code> | If key is not found, d is returned if given, otherwise <code>KeyError</code> is raised |
| <code>popitem()</code> | 2-tuple; but raise <code>KeyError</code> if D is empty. |
| <code>resolve_field_dependencies(fields[, fcache, ...])</code> | Divide fields into those to be read and those to generate. |
| <code>setdefault</code> | Insert key with a value of default if key is not in the dictionary. |
| <code>setup_aliases()</code> | Add aliases defined in the <code>alias_fields</code> tuple for each frontend. |
| <code>setup_derived_fields()</code> | Add stock derived fields. |
| <code>setup_known_fields()</code> | Add units for fields on disk as defined in the <code>known_fields</code> tuple. |
| <code>setup_vector_fields()</code> | Add vector and magnitude fields. |
| <code>update([E,]**F)</code> | If E is present and has a <code>.keys()</code> method, then does: for k in E: <code>D[k] = E[k]</code> If E is present and lacks a <code>.keys()</code> method, then does: for k, v in E: <code>D[k] = v</code> In either case, this is followed by: for k in F: <code>D[k] = F[k]</code> |
| <code>values()</code> | |

Attributes

| |
|----------------------------|
| <code>alias_fields</code> |
| <code>known_fields</code> |
| <code>vector_fields</code> |

ytree.data_structures.fields.FieldContainer

class `ytree.data_structures.fields.FieldContainer` (*arbor*)

A container for field data.

__init__ (*arbor*)

Initialize self. See `help(type(self))` for accurate signature.

Methods

| | |
|--|--|
| <code>__init__</code> (<i>arbor</i>) | Initialize self. |
| <code>clear()</code> | |
| <code>copy()</code> | |
| <code>fromkeys</code> | Create a new dictionary with keys from iterable and values set to value. |
| <code>get</code> | Return the value for key if key is in the dictionary, else default. |
| <code>items()</code> | |
| <code>keys()</code> | |
| <code>pop(k[,d])</code> | If key is not found, d is returned if given, otherwise <code>KeyError</code> is raised |

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| | |
|-------------------------------|--|
| <code>popitem()</code> | 2-tuple; but raise <code>KeyError</code> if <code>D</code> is empty. |
| <code>setdefault</code> | Insert key with a value of default if key is not in the dictionary. |
| <code>update([E,]**F)</code> | If <code>E</code> is present and has a <code>.keys()</code> method, then does: for <code>k</code> in <code>E</code> : <code>D[k] = E[k]</code> If <code>E</code> is present and lacks a <code>.keys()</code> method, then does: for <code>k, v</code> in <code>E</code> : <code>D[k] = v</code> In either case, this is followed by: for <code>k</code> in <code>F</code> : <code>D[k] = F[k]</code> |
| <code>values()</code> | |

ytree.data_structures.fields.FakeFieldContainer

class `ytree.data_structures.fields.FakeFieldContainer` (*arbor*, *name=None*)

A fake field data container used to calculate dependencies.

__init__ (*arbor*, *name=None*)

Initialize self. See `help(type(self))` for accurate signature.

Methods

| | |
|--|--|
| <code>__init__</code> (<i>arbor</i> [, <i>name</i>]) | Initialize self. |
| <code>clear()</code> | |
| <code>copy()</code> | |
| <code>fromkeys</code> | Create a new dictionary with keys from iterable and values set to value. |
| <code>get</code> | Return the value for key if key is in the dictionary, else default. |
| <code>items()</code> | |
| <code>keys()</code> | |
| <code>pop(k[,d])</code> | If key is not found, <code>d</code> is returned if given, otherwise <code>KeyError</code> is raised |
| <code>popitem()</code> | 2-tuple; but raise <code>KeyError</code> if <code>D</code> is empty. |
| <code>setdefault</code> | Insert key with a value of default if key is not in the dictionary. |
| <code>update([E,]**F)</code> | If <code>E</code> is present and has a <code>.keys()</code> method, then does: for <code>k</code> in <code>E</code> : <code>D[k] = E[k]</code> If <code>E</code> is present and lacks a <code>.keys()</code> method, then does: for <code>k, v</code> in <code>E</code> : <code>D[k] = v</code> In either case, this is followed by: for <code>k</code> in <code>F</code> : <code>D[k] = F[k]</code> |
| <code>values()</code> | |

Attributes

| | |
|------------------------------|--|
| <code>default_factory</code> | Factory for default value called by <code>__missing__()</code> . |
|------------------------------|--|

ytree.data_structures.io.FieldIO

class `ytree.data_structures.io.FieldIO` (*arbor*)

Base class for `FieldIO` classes.

This object is responsible for field i/o for an Arbor.

`__init__(arbor)`

Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|--|
| <code>__init__(arbor)</code> | Initialize self. |
| <code>get_fields(data_object[, fields])</code> | Load field data for a data object into storage structures. |

ytree.data_structures.io.TreeFieldIO

class ytree.data_structures.io.TreeFieldIO(*arbor*)

IO class for getting fields for a tree.

`__init__(arbor)`

Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|--|
| <code>__init__(arbor)</code> | Initialize self. |
| <code>get_fields(data_object[, fields])</code> | Load field data for a data object into storage structures. |

ytree.data_structures.io.DefaultRootFieldIO

class ytree.data_structures.io.DefaultRootFieldIO(*arbor*)

Class for getting root fields from arbors that have no specialized storage for root fields.

`__init__(arbor)`

Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|--|
| <code>__init__(arbor)</code> | Initialize self. |
| <code>get_fields(data_object[, fields])</code> | Load field data for a data object into storage structures. |

ytree.data_structures.io.DataFile

class ytree.data_structures.io.DataFile(*filename*)

Base class for data files.

This class allows us keep files open during i/o heavy operations and to keep things like caches of fields.

`__init__(filename)`

Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|---------------------------------|------------------|
| <code>__init__(filename)</code> | Initialize self. |
| <code>close()</code> | |
| <code>open()</code> | |

ytree.data_structures.io.CatalogDataFile

class ytree.data_structures.io.CatalogDataFile (*filename, arbor*)
Base class for halo catalog files.

`__init__` (*filename, arbor*)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|------------------|
| <code>__init__(filename, arbor)</code> | Initialize self. |
| <code>close()</code> | |
| <code>open()</code> | |

ytree.data_structures.tree_node.TreeNode

class ytree.data_structures.tree_node.TreeNode (*uid, arbor=None, root=False*)
Class for objects stored in Arbors.

Each TreeNode represents a halo in a tree. A TreeNode knows its halo ID, the level in the tree, and its global ID in the Arbor that holds it. It also has a list of its ancestors. Fields can be queried for it, its progenitor list, and the tree beneath.

`__init__` (*uid, arbor=None, root=False*)
Initialize a TreeNode with at least its halo catalog ID and its level in the tree.

Methods

| | |
|--|---|
| <code>__init__(uid[, arbor, root])</code> | Initialize a TreeNode with at least its halo catalog ID and its level in the tree. |
| <code>add_ancestor(ancestor)</code> | Add another TreeNode to the list of ancestors. |
| <code>clear_fields()</code> | If a root node, delete field data. |
| <code>find_root()</code> | Find the root node. |
| <code>pwalk()</code> | An iterator over all TreeNodes in the progenitor list, starting with this TreeNode. |
| <code>query(key)</code> | Return field values for this TreeNode, progenitor list, or tree. |
| <code>reset()</code> | Reset all data structures. |
| <code>save_tree([filename, fields])</code> | Save the tree to a file. |
| <code>twalk()</code> | An iterator over all TreeNodes in the tree beneath, starting with this TreeNode. |

Attributes

| |
|-----------|
| ancestors |
| desc_uids |
| is_root |
| nodes |
| tree_size |
| uids |

ytree.frontends.ahf.arbor.AHFArbor

class ytree.frontends.ahf.arbor.**AHFArbor** (*filename*, *hubble_constant=1.0*)

Arbor for Amiga Halo Finder data.

__init__ (*filename*, *hubble_constant=1.0*)

Initialize an Arbor given an input file.

Methods

| | |
|--|--|
| __init__ (<i>filename</i> [, <i>hubble_constant</i>]) | Initialize an Arbor given an input file. |
| add_alias_field (<i>alias</i> , <i>field</i> [, <i>units</i> , <i>force_add</i>]) | Add a field as an alias to another field. |
| add_analysis_field (<i>name</i> , <i>units</i>) | Add an empty field to be filled by analysis operations. |
| add_derived_field (<i>name</i> , <i>function</i> [, <i>units</i> , ...]) | Add a field that is a function of other fields. |
| is_grown (<i>tree_node</i>) | Return True if a tree has been fully assembled, i.e., the hierarchy of ancestor tree nodes has been built. |
| is_setup (<i>tree_node</i>) | Return True if arrays of uids and descendent uids have been read in. |
| query (<i>key</i>) | If given a string, return an array of field values for the roots of all trees. |
| save_arbor ([<i>filename</i> , <i>fields</i> , <i>trees</i> , ...]) | Save the arbor to a file. |
| select_halos (<i>criteria</i> [, <i>trees</i> , <i>select_from</i> , ...]) | Select halos from the arbor based on a set of criteria given as a string. |
| set_selector (<i>selector</i> , * <i>args</i> , ** <i>kwargs</i>) | Sets the tree node selector to be used. |

Attributes

| | |
|-----------------|---|
| arr | Create a YTArray using the Arbor's unit registry. |
| box_size | The simulation box size. |
| field_info | A dictionary containing information for each available field. |
| hubble_constant | Value of the Hubble parameter. |
| quan | Create a YTQuantity using the Arbor's unit registry. |
| size | Return length of tree list. |
| trees | Array containing all trees in the arbor. |
| unit_registry | Unit system registry. |

ytree.frontends.ahf.fields.AHFFieldInfo**class** ytree.frontends.ahf.fields.**AHFFieldInfo**(*arbor*)

__init__(*arbor*)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|---|
| <code>__init__</code> (<i>arbor</i>) | Initialize self. |
| <code>clear</code> () | |
| <code>copy</code> () | |
| <code>fromkeys</code> | Create a new dictionary with keys from iterable and values set to value. |
| <code>get</code> | Return the value for key if key is in the dictionary, else default. |
| <code>items</code> () | |
| <code>keys</code> () | |
| <code>pop</code> (<i>k</i> , <i>d</i>) | If key is not found, <i>d</i> is returned if given, otherwise <code>KeyError</code> is raised |
| <code>popitem</code> () | 2-tuple; but raise <code>KeyError</code> if <i>D</i> is empty. |
| <code>resolve_field_dependencies</code> (<i>fields</i> [, <i>fcache</i> , ...]) | Divide fields into those to be read and those to generate. |
| <code>setdefault</code> | Insert key with a value of default if key is not in the dictionary. |
| <code>setup_aliases</code> () | Add aliases defined in the <code>alias_fields</code> tuple for each frontend. |
| <code>setup_derived_fields</code> () | Add stock derived fields. |
| <code>setup_known_fields</code> () | Add units for fields on disk as defined in the <code>known_fields</code> tuple. |
| <code>setup_vector_fields</code> () | Add vector and magnitude fields. |
| <code>update</code> (<i>E</i> , <i>l</i> ** <i>F</i>) | If <i>E</i> is present and has a <code>.keys()</code> method, then does: for <i>k</i> in <i>E</i> : <i>D</i> [<i>k</i>] = <i>E</i> [<i>k</i>] If <i>E</i> is present and lacks a <code>.keys()</code> method, then does: for <i>k</i> , <i>v</i> in <i>E</i> : <i>D</i> [<i>k</i>] = <i>v</i> In either case, this is followed by: for <i>k</i> in <i>F</i> : <i>D</i> [<i>k</i>] = <i>F</i> [<i>k</i>] |
| <code>values</code> () | |

Attributes

| |
|----------------------------|
| <code>alias_fields</code> |
| <code>known_fields</code> |
| <code>vector_fields</code> |

ytree.frontends.ahf.io.AHFDataFile**class** ytree.frontends.ahf.io.**AHFDataFile**(*filename*, *arbor*)

__init__(*filename*, *arbor*)

Initialize self. See `help(type(self))` for accurate signature.

Methods

| | |
|--|------------------|
| <code>__init__(filename, arbor)</code> | Initialize self. |
| <code>close()</code> | |
| <code>open()</code> | |

Attributes

| | |
|--------------------|--|
| <code>links</code> | |
|--------------------|--|

ytree.frontends.arborarbor.arbor.ArborArbor

class ytree.frontends.arborarbor.arbor.**ArborArbor** (*filename*)

Class for Arbors created with ytree version 1.1.0 or earlier.

`__init__(filename)`

Initialize an Arbor given an input file.

Methods

| | |
|--|--|
| <code>__init__(filename)</code> | Initialize an Arbor given an input file. |
| <code>add_alias_field(alias, field[, units, force_add])</code> | Add a field as an alias to another field. |
| <code>add_analysis_field(name, units)</code> | Add an empty field to be filled by analysis operations. |
| <code>add_derived_field(name, function[, units, ...])</code> | Add a field that is a function of other fields. |
| <code>is_grown(tree_node)</code> | Return True if a tree has been fully assembled, i.e., the hierarchy of ancestor tree nodes has been built. |
| <code>is_setup(tree_node)</code> | Return True if arrays of uids and descendent uids have been read in. |
| <code>query(key)</code> | If given a string, return an array of field values for the roots of all trees. |
| <code>save_arbor([filename, fields, trees, ...])</code> | Save the arbor to a file. |
| <code>select_halos(criteria[, trees, select_from, ...])</code> | Select halos from the arbor based on a set of criteria given as a string. |
| <code>set_selector(selector, *args, **kwargs)</code> | Sets the tree node selector to be used. |

Attributes

| | |
|------------------------------|---|
| <code>arr</code> | Create a YTArray using the Arbor's unit registry. |
| <code>box_size</code> | The simulation box size. |
| <code>field_info</code> | A dictionary containing information for each available field. |
| <code>hubble_constant</code> | Value of the Hubble parameter. |

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| | |
|---------------|--|
| quan | Create a YTQuantity using the Arbor's unit registry. |
| size | Return length of tree list. |
| trees | Array containing all trees in the arbor. |
| unit_registry | Unit system registry. |

ytree.frontends.arborarbor.fields.ArborArborFieldInfo**class** ytree.frontends.arborarbor.fields.**ArborArborFieldInfo**(*arbor*)**__init__**(*arbor*)

Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|---|
| __init__ (<i>arbor</i>) | Initialize self. |
| clear() | |
| copy() | |
| fromkeys | Create a new dictionary with keys from iterable and values set to value. |
| get | Return the value for key if key is in the dictionary, else default. |
| items() | |
| keys() | |
| pop(<i>k</i> , <i>d</i>) | If key is not found, <i>d</i> is returned if given, otherwise KeyError is raised |
| popitem() | 2-tuple; but raise KeyError if <i>D</i> is empty. |
| resolve_field_dependencies(<i>fields</i> [, <i>fcache</i> , ...]) | Divide fields into those to be read and those to generate. |
| setdefault | Insert key with a value of default if key is not in the dictionary. |
| setup_aliases() | Add aliases defined in the <i>alias_fields</i> tuple for each frontend. |
| setup_derived_fields() | Add stock derived fields. |
| setup_known_fields() | Add units for fields on disk as defined in the <i>known_fields</i> tuple. |
| setup_vector_fields() | Add vector and magnitude fields. |
| update(<i>[E,]**F</i>) | If <i>E</i> is present and has a .keys() method, then does: for <i>k</i> in <i>E</i> : <i>D</i> [<i>k</i>] = <i>E</i> [<i>k</i>] If <i>E</i> is present and lacks a .keys() method, then does: for <i>k</i> , <i>v</i> in <i>E</i> : <i>D</i> [<i>k</i>] = <i>v</i> In either case, this is followed by: for <i>k</i> in <i>F</i> : <i>D</i> [<i>k</i>] = <i>F</i> [<i>k</i>] |
| values() | |

Attributes

| |
|----------------------|
| <i>alias_fields</i> |
| <i>known_fields</i> |
| <i>vector_fields</i> |

ytree.frontends.arborarbor.io.ArborArborTreeFieldIO

class ytree.frontends.arborarbor.io.ArborArborTreeFieldIO(*arbor*)

__init__(*arbor*)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|--|
| <u>__init__</u> (<i>arbor</i>) | Initialize self. |
| get_fields (<i>data_object</i> [, <i>fields</i>]) | Load field data for a data object into storage structures. |

ytree.frontends.arborarbor.io.ArborArborRootFieldIO

class ytree.frontends.arborarbor.io.ArborArborRootFieldIO(*arbor*)

__init__(*arbor*)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|--|
| <u>__init__</u> (<i>arbor</i>) | Initialize self. |
| get_fields (<i>data_object</i> [, <i>fields</i>]) | Load field data for a data object into storage structures. |

ytree.frontends.consistent_trees.arbor.ConsistentTreesArbor

class ytree.frontends.consistent_trees.arbor.ConsistentTreesArbor(*filename*)
Arbors from consistent-trees output files.

__init__(*filename*)
Initialize an Arbor given an input file.

Methods

| | |
|--|--|
| <u>__init__</u> (<i>filename</i>) | Initialize an Arbor given an input file. |
| add_alias_field (<i>alias</i> , <i>field</i> [, <i>units</i> , <i>force_add</i>]) | Add a field as an alias to another field. |
| add_analysis_field (<i>name</i> , <i>units</i>) | Add an empty field to be filled by analysis operations. |
| add_derived_field (<i>name</i> , <i>function</i> [, <i>units</i> , ...]) | Add a field that is a function of other fields. |
| is_grown (<i>tree_node</i>) | Return True if a tree has been fully assembled, i.e., the hierarchy of ancestor tree nodes has been built. |

Continued on next page

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| | |
|--|--|
| <code>is_setup(tree_node)</code> | Return True if arrays of uids and descendent uids have been read in. |
| <code>query(key)</code> | If given a string, return an array of field values for the roots of all trees. |
| <code>save_arbor([filename, fields, trees, ...])</code> | Save the arbor to a file. |
| <code>select_halos(criteria[, trees, select_from, ...])</code> | Select halos from the arbor based on a set of criteria given as a string. |
| <code>set_selector(selector, *args, **kwargs)</code> | Sets the tree node selector to be used. |

Attributes

| | |
|------------------------------|---|
| <code>arr</code> | Create a YTArray using the Arbor’s unit registry. |
| <code>box_size</code> | The simulation box size. |
| <code>field_info</code> | A dictionary containing information for each available field. |
| <code>hubble_constant</code> | Value of the Hubble parameter. |
| <code>quan</code> | Create a YTQuantity using the Arbor’s unit registry. |
| <code>size</code> | Return length of tree list. |
| <code>trees</code> | Array containing all trees in the arbor. |
| <code>unit_registry</code> | Unit system registry. |

ytree.frontends.consistent_trees.fields.ConsistentTreesFieldInfo

class `ytree.frontends.consistent_trees.fields.ConsistentTreesFieldInfo` (*arbor*)

__init__ (*arbor*)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|---|
| <code>__init__(arbor)</code> | Initialize self. |
| <code>clear()</code> | |
| <code>copy()</code> | |
| <code>fromkeys</code> | Create a new dictionary with keys from iterable and values set to value. |
| <code>get</code> | Return the value for key if key is in the dictionary, else default. |
| <code>items()</code> | |
| <code>keys()</code> | |
| <code>pop(k[,d])</code> | If key is not found, d is returned if given, otherwise KeyError is raised |
| <code>popitem()</code> | 2-tuple; but raise KeyError if D is empty. |
| <code>resolve_field_dependencies(fields[, fcache, ...])</code> | Divide fields into those to be read and those to generate. |
| <code>setdefault</code> | Insert key with a value of default if key is not in the dictionary. |
| <code>setup_aliases()</code> | Add aliases defined in the alias_fields tuple for each frontend. |

Continued on next page

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| | |
|-------------------------------------|--|
| <code>setup_derived_fields()</code> | Add stock derived fields. |
| <code>setup_known_fields()</code> | Add units for fields on disk as defined in the <code>known_fields</code> tuple. |
| <code>setup_vector_fields()</code> | Add vector and magnitude fields. |
| <code>update([E,]**F)</code> | If E is present and has a <code>.keys()</code> method, then does: for k in E: D[k] = E[k] If E is present and lacks a <code>.keys()</code> method, then does: for k, v in E: D[k] = v In either case, this is followed by: for k in F: D[k] = F[k] |
| <code>values()</code> | |

Attributes

| |
|----------------------------|
| <code>alias_fields</code> |
| <code>known_fields</code> |
| <code>vector_fields</code> |

ytree.frontends.consistent_trees.io.ConsistentTreesDataFile

class ytree.frontends.consistent_trees.io.**ConsistentTreesDataFile** (*filename*)

__init__ (*filename*)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|---|------------------|
| <code>__init__</code> (<i>filename</i>) | Initialize self. |
| <code>close()</code> | |
| <code>open()</code> | |

ytree.frontends.consistent_trees.io.ConsistentTreesTreeFieldIO

class ytree.frontends.consistent_trees.io.**ConsistentTreesTreeFieldIO** (*arbor*)

__init__ (*arbor*)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|--|
| <code>__init__</code> (<i>arbor</i>) | Initialize self. |
| <code>get_fields</code> (<i>data_object</i> [, <i>fields</i>]) | Load field data for a data object into storage structures. |

ytree.frontends.lhalotree.arbor.LHaloTreeArbor

```
class ytree.frontends.lhalotree.arbor.LHaloTreeArbor (*args, **kwargs)
    Arbors for LHaloTree data.

    __init__ (*args, **kwargs)
        Added reader class to allow fast access of header info.
```

Methods

| | |
|--|--|
| <code>__init__(*args, **kwargs)</code> | Added reader class to allow fast access of header info. |
| <code>add_alias_field(alias, field[, units, force_add])</code> | Add a field as an alias to another field. |
| <code>add_analysis_field(name, units)</code> | Add an empty field to be filled by analysis operations. |
| <code>add_derived_field(name, function[, units, ...])</code> | Add a field that is a function of other fields. |
| <code>is_grown(tree_node)</code> | Return True if a tree has been fully assembled, i.e., the hierarchy of ancestor tree nodes has been built. |
| <code>is_setup(tree_node)</code> | Return True if arrays of uids and descendent uids have been read in. |
| <code>query(key)</code> | If given a string, return an array of field values for the roots of all trees. |
| <code>save_arbor([filename, fields, trees, ...])</code> | Save the arbor to a file. |
| <code>select_halos(criteria[, trees, select_from, ...])</code> | Select halos from the arbor based on a set of criteria given as a string. |
| <code>set_selector(selector, *args, **kwargs)</code> | Sets the tree node selector to be used. |

Attributes

| | |
|------------------------------|---|
| <code>arr</code> | Create a YTArray using the Arbor's unit registry. |
| <code>box_size</code> | The simulation box size. |
| <code>field_info</code> | A dictionary containing information for each available field. |
| <code>hubble_constant</code> | Value of the Hubble parameter. |
| <code>quan</code> | Create a YTQuantity using the Arbor's unit registry. |
| <code>size</code> | Return length of tree list. |
| <code>trees</code> | Array containing all trees in the arbor. |
| <code>unit_registry</code> | Unit system registry. |

ytree.frontends.lhalotree.fields.LHaloTreeFieldInfo

```
class ytree.frontends.lhalotree.fields.LHaloTreeFieldInfo (arbor)

    __init__ (arbor)
        Initialize self. See help(type(self)) for accurate signature.
```


Methods

| | |
|--|--|
| <code>__init__(arbor)</code> | Initialize self. |
| <code>clear()</code> | |
| <code>copy()</code> | |
| <code>fromkeys</code> | Create a new dictionary with keys from iterable and values set to value. |
| <code>get</code> | Return the value for key if key is in the dictionary, else default. |
| <code>items()</code> | |
| <code>keys()</code> | |
| <code>pop(k[,d])</code> | If key is not found, d is returned if given, otherwise KeyError is raised |
| <code>popitem()</code> | 2-tuple; but raise KeyError if D is empty. |
| <code>resolve_field_dependencies(fields[, fcache, ...])</code> | Divide fields into those to be read and those to generate. |
| <code>setdefault</code> | Insert key with a value of default if key is not in the dictionary. |
| <code>setup_aliases()</code> | Add aliases defined in the <code>alias_fields</code> tuple for each frontend. |
| <code>setup_derived_fields()</code> | Add stock derived fields. |
| <code>setup_known_fields()</code> | Add units for fields on disk as defined in the <code>known_fields</code> tuple. |
| <code>setup_vector_fields()</code> | Add vector and magnitude fields. |
| <code>update([E,]**F)</code> | If E is present and has a <code>.keys()</code> method, then does: for k in E: D[k] = E[k] If E is present and lacks a <code>.keys()</code> method, then does: for k, v in E: D[k] = v In either case, this is followed by: for k in F: D[k] = F[k] |
| <code>values()</code> | |

Attributes

| |
|----------------------------|
| <code>alias_fields</code> |
| <code>known_fields</code> |
| <code>vector_fields</code> |

ytree.frontends.lhalotree.io.LHaloTreeTreeFieldIO

class ytree.frontends.lhalotree.io.LHaloTreeTreeFieldIO(*arbor*)

`__init__(arbor)`
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|------------------------------|------------------|
| <code>__init__(arbor)</code> | Initialize self. |
|------------------------------|------------------|

Continued on next page

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| | |
|--|--|
| <code>get_fields(data_object[, fields])</code> | Load field data for a data object into storage structures. |
|--|--|

ytree.frontends.lhalotree.io.LHaloTreeRootFieldIO

class ytree.frontends.lhalotree.io.LHaloTreeRootFieldIO(*arbor*)

`__init__`(*arbor*)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|--|
| <code>__init__</code> (<i>arbor</i>) | Initialize self. |
| <code>get_fields(data_object[, fields])</code> | Load field data for a data object into storage structures. |

ytree.frontends.rockstar.arbor.RockstarArbor

class ytree.frontends.rockstar.arbor.RockstarArbor(*filename*)

Class for Arbors created from Rockstar out_*.list files. Use only descendent IDs to determine tree relationship.

`__init__`(*filename*)
Initialize an Arbor given an input file.

Methods

| | |
|--|--|
| <code>__init__</code> (<i>filename</i>) | Initialize an Arbor given an input file. |
| <code>add_alias_field(alias, field[, units, force_add])</code> | Add a field as an alias to another field. |
| <code>add_analysis_field(name, units)</code> | Add an empty field to be filled by analysis operations. |
| <code>add_derived_field(name, function[, units, ...])</code> | Add a field that is a function of other fields. |
| <code>is_grown(tree_node)</code> | Return True if a tree has been fully assembled, i.e., the hierarchy of ancestor tree nodes has been built. |
| <code>is_setup(tree_node)</code> | Return True if arrays of uids and descendent uids have been read in. |
| <code>query(key)</code> | If given a string, return an array of field values for the roots of all trees. |
| <code>save_arbor([filename, fields, trees, ...])</code> | Save the arbor to a file. |
| <code>select_halos(criteria[, trees, select_from, ...])</code> | Select halos from the arbor based on a set of criteria given as a string. |
| <code>set_selector(selector, *args, **kwargs)</code> | Sets the tree node selector to be used. |

Attributes

| | |
|------------------------------|---|
| <code>arr</code> | Create a YTArray using the Arbor's unit registry. |
| <code>box_size</code> | The simulation box size. |
| <code>field_info</code> | A dictionary containing information for each available field. |
| <code>hubble_constant</code> | Value of the Hubble parameter. |
| <code>quan</code> | Create a YTQuantity using the Arbor's unit registry. |
| <code>size</code> | Return length of tree list. |
| <code>trees</code> | Array containing all trees in the arbor. |
| <code>unit_registry</code> | Unit system registry. |

ytree.frontends.rockstar.fields.RockstarFieldInfo

class ytree.frontends.rockstar.fields.RockstarFieldInfo (*arbor*)

__init__ (*arbor*)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|--|
| <code>__init__</code> (<i>arbor</i>) | Initialize self. |
| <code>clear()</code> | |
| <code>copy()</code> | |
| <code>fromkeys</code> | Create a new dictionary with keys from iterable and values set to value. |
| <code>get</code> | Return the value for key if key is in the dictionary, else default. |
| <code>items()</code> | |
| <code>keys()</code> | |
| <code>pop(k[,d])</code> | If key is not found, d is returned if given, otherwise KeyError is raised |
| <code>popitem()</code> | 2-tuple; but raise KeyError if D is empty. |
| <code>resolve_field_dependencies(fields[, fcache, ...])</code> | Divide fields into those to be read and those to generate. |
| <code>setdefault</code> | Insert key with a value of default if key is not in the dictionary. |
| <code>setup_aliases()</code> | Add aliases defined in the alias_fields tuple for each frontend. |
| <code>setup_derived_fields()</code> | Add stock derived fields. |
| <code>setup_known_fields()</code> | Add units for fields on disk as defined in the known_fields tuple. |
| <code>setup_vector_fields()</code> | Add vector and magnitude fields. |
| <code>update([E,]**F)</code> | If E is present and has a .keys() method, then does: for k in E: D[k] = E[k] If E is present and lacks a .keys() method, then does: for k, v in E: D[k] = v In either case, this is followed by: for k in F: D[k] = F[k] |
| <code>values()</code> | |

Attributes

| |
|----------------------------|
| <code>alias_fields</code> |
| <code>known_fields</code> |
| <code>vector_fields</code> |

ytree.frontends.rockstar.io.RockstarDataFile

class ytree.frontends.rockstar.io.RockstarDataFile (*filename*, *arbor*)

__init__ (*filename*, *arbor*)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|------------------|
| <code>__init__</code> (<i>filename</i> , <i>arbor</i>) | Initialize self. |
| <code>close</code> () | |
| <code>open</code> () | |

ytree.frontends.treefarm.arbor.TreeFarmArbor

class ytree.frontends.treefarm.arbor.TreeFarmArbor (*filename*)

Class for Arbors created with TreeFarm.

__init__ (*filename*)
Initialize an Arbor given an input file.

Methods

| | |
|--|--|
| <code>__init__</code> (<i>filename</i>) | Initialize an Arbor given an input file. |
| <code>add_alias_field</code> (<i>alias</i> , <i>field</i> [, <i>units</i> , <i>force_add</i>]) | Add a field as an alias to another field. |
| <code>add_analysis_field</code> (<i>name</i> , <i>units</i>) | Add an empty field to be filled by analysis operations. |
| <code>add_derived_field</code> (<i>name</i> , <i>function</i> [, <i>units</i> , ...]) | Add a field that is a function of other fields. |
| <code>is_grown</code> (<i>tree_node</i>) | Return True if a tree has been fully assembled, i.e., the hierarchy of ancestor tree nodes has been built. |
| <code>is_setup</code> (<i>tree_node</i>) | Return True if arrays of uids and descendent uids have been read in. |
| <code>query</code> (<i>key</i>) | If given a string, return an array of field values for the roots of all trees. |
| <code>save_arbor</code> ([<i>filename</i> , <i>fields</i> , <i>trees</i> , ...]) | Save the arbor to a file. |
| <code>select_halos</code> (<i>criteria</i> [, <i>trees</i> , <i>select_from</i> , ...]) | Select halos from the arbor based on a set of criteria given as a string. |
| <code>set_selector</code> (<i>selector</i> , * <i>args</i> , ** <i>kwargs</i>) | Sets the tree node selector to be used. |

Attributes

| | |
|------------------------------|---|
| <code>arr</code> | Create a YTArray using the Arbor's unit registry. |
| <code>box_size</code> | The simulation box size. |
| <code>field_info</code> | A dictionary containing information for each available field. |
| <code>hubble_constant</code> | Value of the Hubble parameter. |
| <code>quan</code> | Create a YTQuantity using the Arbor's unit registry. |
| <code>size</code> | Return length of tree list. |
| <code>trees</code> | Array containing all trees in the arbor. |
| <code>unit_registry</code> | Unit system registry. |

ytree.frontends.treefarm.fields.TreeFarmFieldInfo

class ytree.frontends.treefarm.fields.**TreeFarmFieldInfo**(*arbor*)

__init__(*arbor*)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|--|
| <code>__init__</code> (<i>arbor</i>) | Initialize self. |
| <code>clear</code> () | |
| <code>copy</code> () | |
| <code>fromkeys</code> | Create a new dictionary with keys from iterable and values set to value. |
| <code>get</code> | Return the value for key if key is in the dictionary, else default. |
| <code>items</code> () | |
| <code>keys</code> () | |
| <code>pop</code> (<i>k</i> , <i>d</i>) | If key is not found, d is returned if given, otherwise KeyError is raised |
| <code>popitem</code> () | 2-tuple; but raise KeyError if D is empty. |
| <code>resolve_field_dependencies</code> (<i>fields</i> [, <i>fcache</i> , ...]) | Divide fields into those to be read and those to generate. |
| <code>setdefault</code> | Insert key with a value of default if key is not in the dictionary. |
| <code>setup_aliases</code> () | Add aliases defined in the <code>alias_fields</code> tuple for each frontend. |
| <code>setup_derived_fields</code> () | Add stock derived fields. |
| <code>setup_known_fields</code> () | Add units for fields on disk as defined in the <code>known_fields</code> tuple. |
| <code>setup_vector_fields</code> () | Add vector and magnitude fields. |
| <code>update</code> (<i>[E,]**F</i>) | If E is present and has a <code>.keys()</code> method, then does: for k in E: D[k] = E[k] If E is present and lacks a <code>.keys()</code> method, then does: for k, v in E: D[k] = v In either case, this is followed by: for k in F: D[k] = F[k] |
| <code>values</code> () | |

Attributes

| |
|----------------------------|
| <code>alias_fields</code> |
| <code>known_fields</code> |
| <code>vector_fields</code> |

ytree.frontends.treefarm.io.TreeFarmDataFile

class ytree.frontends.treefarm.io.TreeFarmDataFile(*filename*, *arbor*)

__init__(*filename*, *arbor*)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|------------------|
| <code>__init__</code> (<i>filename</i> , <i>arbor</i>) | Initialize self. |
| <code>close</code> () | |
| <code>open</code> () | |

ytree.frontends.treefarm.io.TreeFarmTreeFieldIO

class ytree.frontends.treefarm.io.TreeFarmTreeFieldIO(*arbor*)

__init__(*arbor*)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|--|
| <code>__init__</code> (<i>arbor</i>) | Initialize self. |
| <code>get_fields</code> (<i>data_object</i> [, <i>fields</i>]) | Load field data for a data object into storage structures. |

ytree.frontends.ytree.arbor.YTreeArbor

class ytree.frontends.ytree.arbor.YTreeArbor(*filename*)
Class for Arbors created from the `save_arbor` or `save_tree` functions.

__init__(*filename*)
Initialize an Arbor given an input file.

Methods

| | |
|--|---|
| <code>__init__</code> (<i>filename</i>) | Initialize an Arbor given an input file. |
| <code>add_alias_field</code> (<i>alias</i> , <i>field</i> [, <i>units</i> , <i>force_add</i>]) | Add a field as an alias to another field. |

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| | |
|--|--|
| <code>add_analysis_field(name, units)</code> | Add an empty field to be filled by analysis operations. |
| <code>add_derived_field(name, function[, units, ...])</code> | Add a field that is a function of other fields. |
| <code>is_grown(tree_node)</code> | Return True if a tree has been fully assembled, i.e., the hierarchy of ancestor tree nodes has been built. |
| <code>is_setup(tree_node)</code> | Return True if arrays of uids and descendent uids have been read in. |
| <code>query(key)</code> | If given a string, return an array of field values for the roots of all trees. |
| <code>save_arbor([filename, fields, trees, ...])</code> | Save the arbor to a file. |
| <code>select_halos(criteria[, trees, select_from, ...])</code> | Select halos from the arbor based on a set of criteria given as a string. |
| <code>set_selector(selector, *args, **kwargs)</code> | Sets the tree node selector to be used. |

Attributes

| | |
|------------------------------|---|
| <code>arr</code> | Create a YTArray using the Arbor’s unit registry. |
| <code>box_size</code> | The simulation box size. |
| <code>field_info</code> | A dictionary containing information for each available field. |
| <code>hubble_constant</code> | Value of the Hubble parameter. |
| <code>quan</code> | Create a YTQuantity using the Arbor’s unit registry. |
| <code>size</code> | Return length of tree list. |
| <code>trees</code> | Array containing all trees in the arbor. |
| <code>unit_registry</code> | Unit system registry. |

ytree.frontends.ytree.io.YTreeDataFile

class `ytree.frontends.ytree.io.YTreeDataFile` (*filename*)

__init__ (*filename*)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|---|------------------|
| <code>__init__</code> (<i>filename</i>) | Initialize self. |
| <code>close()</code> | |
| <code>open()</code> | |

ytree.frontends.ytree.io.YTreeTreeFieldIO

class `ytree.frontends.ytree.io.YTreeTreeFieldIO` (*arbor*)

__init__ (*arbor*)
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|--|
| <code>__init__(arbor)</code> | Initialize self. |
| <code>get_fields(data_object[, fields])</code> | Load field data for a data object into storage structures. |

ytree.frontends.ytree.io.YTreeRootFieldIO

class ytree.frontends.ytree.io.YTreeRootFieldIO(*arbor*)

`__init__(arbor)`
Initialize self. See help(type(self)) for accurate signature.

Methods

| | |
|--|--|
| <code>__init__(arbor)</code> | Initialize self. |
| <code>get_fields(data_object[, fields])</code> | Load field data for a data object into storage structures. |

2.14.2 ChangeLog

This is a log of changes to ytree over its release history.

Contributors

The [CREDITS file](#) contains the most up-to-date list of everyone who has contributed to the ytree source code.

Version 2.3

Release date: *December 17, 2019*

This release marks the [acceptance of the ytree paper](#) in JOSS.

This is the last release to support Python 2.

New Features

- Add TreePlot for plotting and examples docs ([PR #39](#))

Enhancements

- Add time field ([PR #25](#))
- Move treefarm module to separate package ([PR #28](#))

Version 2.2.1

Release date: *October 24, 2018*

Enhancements

- Refactor of CatalogDataFile class ([PR #21](#))
- Simplify requirements file for docs build on readthedocs.io ([PR #22](#))

Bugfixes

- Restore access to analysis fields for tree roots ([PR #23](#))
- fix field access on non-root nodes when tree is not setup ([PR #20](#))
- fix issue of uid and desc_uid fields being clobbered during initial field access ([PR #19](#))

Version 2.2

Release date: *August 28, 2018*

New Features

- add vector fields.
- add select_halos function.

Enhancements

- significant refactor of field and i/o systems.
- upgrades to testing infrastructure.

Version 2.1.1

Release date: *April 23, 2018*

Bugfixes

- update environment.yml to fix broken readthedocs build.

Version 2.1

Release date: *April 20, 2018*

New Features

- add support for LHaloTree format.
- add support for Amiga Halo Finder format.

Version 2.0.2

Release date: *February 16, 2018*

Enhancements

- significantly improved i/o for ytree frontend.

Version 2.0

Release date: *August 07, 2017*

This is significant overhaul of the ytree machinery.

New Features

- tree building and field i/o now occur on-demand.
- support for yt-like derived fields that can be defined with simple functions.
- support for yt-like alias fields allowing for universal field naming conventions to simplify writing scripts for multiple data formats.
- support for analysis fields which allow users to save the results of expensive halo analysis to fields associated with each halo.
- all fields in consistent-trees and Rockstar now fully supported with units.
- an optimized format for saving and reloading trees for fast field access.

Enhancements

- significantly improved documentation including a guide to adding support for new file formats.

Version 1.1

Release date: *January 12, 2017*

New Features

- New, more yt-like field querying syntax for both arbors and tree nodes.

Enhancements

- Python3 now supported.
- More robust unit system with restoring of unit registries from stored json.
- Added minimum radius to halo sphere selector.
- Replaced import of yt for specific imports of all required functions.
- Added ytree logger.

- Docs updated and API reference docs added.

Bugfixes

- Allow non-root trees to be saved and reloaded.
- Fix bug allowing trees that end before the final output.

Version 1.0

Release date: *Sep 26, 2016*

The inaugural release of ytree!

CHAPTER 3

Citing ytree

If you use ytree in your work, please cite the following:

Britton Smith, & Meagan Lang. (2018, February 16). ytree: merger-tree toolkit. Zenodo. <http://doi.org/10.5281/zenodo.1174374>

For BibTeX users:

```
@misc{britton_smith_2018_1174374,  
  author      = {Britton Smith and  
                 Meagan Lang},  
  title       = {ytree: merger-tree toolkit},  
  month       = feb,  
  year        = 2018,  
  doi         = {10.5281/zenodo.1174374},  
  url         = {https://doi.org/10.5281/zenodo.1174374}  
}
```

If possible, please also add a footnote pointing to <http://ytree.readthedocs.io>.

CHAPTER 4

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- search

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