

# **Simulations Documentation**

## the AWESOME Project

Markus Haider, Harald Höller

March 23, 2012

# Contents

<b>1 Notes</b>	<b>2</b>
<b>2 Simulations</b>	<b>6</b>
2.1 r128 . . . . .	6
2.1.1 drdx_3 . . . . .	6
2.1.2 drdx_h100_r128_1 . . . . .	8
2.1.3 drdx_h100_r128_2 . . . . .	9
2.1.4 drkltest+3c+sl50_1 . . . . .	10
2.2 r256 . . . . .	12
2.2.1 drd5_r256 . . . . .	12
2.2.2 drd5_r256 (~) . . . . .	14
2.2.3 drd5_r256_2 (+ major merger in progress) . . . . .	17
2.2.4 drdx_3_r256 . . . . .	21
2.2.5 fuenfincr256_1 . . . . .	24
2.2.6 fuenfincr256_2 → dump! . . . . .	27
2.2.7 gendrkl1r2_1c_1 . . . . .	30
2.2.8 NGenIC_10629 . . . . .	35
2.2.9 NGenIC_15039 . . . . .	38
2.2.10 NGenIC_26214 . . . . .	41
2.2.11 stages_07 . . . . .	44
2.2.12 stages_12 . . . . .	48
2.2.13 stages_13 . . . . .	52
2.2.14 stages14_ling . . . . .	56
2.2.15 stages_14 . . . . .	59
2.2.16 stages_14e . . . . .	63
2.2.17 stages_18 . . . . .	64
2.2.18 stages_19 . . . . .	68
2.2.19 stages_20 . . . . .	71
2.2.20 stages_21 . . . . .	75
2.2.21 stages_37 . . . . .	79
2.2.22 stages_46 . . . . .	83
2.2.23 stages_50 . . . . .	84
2.2.24 stages51_ling . . . . .	88
2.2.25 stages_51 . . . . .	90
2.2.26 stages_52 . . . . .	93
2.3 r512 . . . . .	94
2.3.1 512er_major_merger . . . . .	94
2.3.2 NGenIC_7755 . . . . .	96
2.3.3 NGenIC_10939 . . . . .	97
2.3.4 NGenIC_11410 . . . . .	98
2.3.5 NGenIC_27036 . . . . .	99

# Chapter 1

## Notes

21.03.2012 2DO: change virial radius reading in galaxcicusStart.xml to false and let intern value powmes scripts, plotting scripts (spin, vrms)

20.03.2012 powemes installed

19.03.2012 NGenIC starting redshift test, if corrected initial z leads to lower star formation rate did show, that suspicion was not proven. Other explanation has to be found. Vrms and Spin videos are in the works.

14.03.2012 2DO: new stages simulations in Documentation (at least 46, 50, 51)  
Script that makes \*.pngs out of halo masses at all time steps is running over all simulations in r256 for comparison beweteen Bertschinger and NGenIC ICs  
Rerun some Bertschinger ICs with updated linger.dat and spectral index  $\neq 1$  to see how this influences star formation rate (linger runs and runs)

13.03.2012 Unclear why all NGenIC simulations show much higher star formation and plot scripts yield different output files though the same .xml file as always is used

11.03.2012 NGenIC\_15039 produces "unreadable" output, is bein rerockstarred from scratch

```
+++
Plot_Star_Formation_History.pl:
+++
Useless use of private variable in void context at ../../perl//XMP/MetaData.pm line
HDF5-DIAG: Error detected in HDF5 (1.8.4-patch1) thread 0:
#000: ../../src/H5D.c line 507 in H5Dget_type(): not a dataset
    major: Invalid arguments to routine
    minor: Inappropriate type
Error Calling PDL::IO::HDF5::Dataset::get: Can't get HDF5 Dataset type.
    at ../../perl//Galacticus/HDF5.pm line 88
HDF5-DIAG: Error detected in HDF5 (1.8.4-patch1) thread 0:
#000: ../../src/H5D.c line 507 in H5Dget_type(): not a dataset
    major: Invalid arguments to routine
    minor: Inappropriate type
Error Calling PDL::IO::HDF5::Dataset::get: Can't get HDF5 Dataset type.
    at ../../perl//Galacticus/HDF5.pm line 88
Illegal division by zero at Plot_Star_Formation_History.pl line 58.
```

09.03.2012 strange error in 2 galacticus jobs `stages_12` and `stages_13` → Markus' converter outdated with new consistenttrees?

**idea:** drd5\_r256\_2 shows a major merger in progress → make a set of similar simulations with slightly different parameters  
**idea:** make voids as constraints so that netto gravity is more centered towards over-densities

08.03.2012 add nohup to ./rockstar\_server\_ib.cfg in qsubrockstar.sh and rename rocky\_startscript to something recognizable

83973	0.60500	wcon1Gy.st	jan	r	11:01:23	astro14.astro-beowulf.	64
83974	0.50500	rocky_star	harre	r	13:14:22	astro-x4600-04.astro-beo	1
83976	0.55421	stages_28_	harre	r	13:52:36	astro22.astro-beowulf.	32
83977	0.55421	stages_29_	harre	r	13:56:35	astro25.astro-beowulf.	32
83980	0.55421	stages_30_	harre	r	14:07:12	astro28.astro-beowulf.	32
83984	0.55421	stages_31_	harre	r	14:14:23	astro31.astro-beowulf.	32
83988	0.51611	rocky_star	harre	r	14:49:20	astro-x4600-04.astro-beo	8
83989	0.51611	rocky_star	harre	r	14:50:54	astro-x4600-03.astro-beo	8
83993	0.51611	rocky_star	harre	r	15:12:52	astro-x4600-04.astro-beo	8
83995	0.51611	rocky_star	harre	r	15:16:43	astro-x4600-03.astro-beo	8
83992	0.58278	c803_test_	markus	qw	14:54:54		50
83985	0.55421	stages_32_	harre	qw	14:14:31		32
83986	0.55421	stages_33_	harre	qw	14:14:41		32

re-galacticussing NgenIC\_15039 again since plotting scripts complain that there is no output for a=0

2DO: test speedup of galacticus with 1,2,4,8 threads

**Rockstar** works if infiniband is forced with PARALLEL\_IO\_SERVER\_INTERFACE = "ib0", the client IP address is indeed NOT necessary, client process is started with auto-rockstar.cfg Gadget recompiled with newest openmpi version → should use infiniband now

06.03.2012 submitted 4 jobs with same seed but different constraints parameters

Memory agglomeration fix also on cluster + email to developer

Wrote E-Mails to Rien de Weijgaert and Peter Behroozi

re-rockstarring stages\_21 on my machine pc122 → dumped due to memory

02.03.2012 re-galacticussing NgenIC\_15039 cause 200 output redshifts lead to > 30GB file + added luminosity output redshifts from Markus' .xml file

Peter answered and sent consistent\_trees v0.99, but problem persists - suspicion: Snapshotnames.dat must be changed (delete corresponding lines) for runs that have < 200 outputs!

rockstar won't start any more ... network problem suspected

01.03.2012 wrote E-Mail to Peter concerning find\_parents\_and\_cleanup:

find\_parents\_and\_cleanup.c:130 problem

consistenttree: NgenIC\_15039, galacticussing

restarted: stages\_21 rockstarred auf AMD-04

first 512<sup>3</sup> simulation NgenIC\_7755 finished successfully - lasted 1 day on 64 cores

wrote E-mail to de Weijgaert concerning constrained ICs

29.02.2012 stages\_12 re-rockstarred auf AMD-03

stages\_21 rockstarred auf AMD-04 - crashed

100Mpc 512<sup>3</sup> jobs: 11410, 15725, 27036, 7755

10 100Mpc ICs generated

**Note: try bigger volumes with NGen-IC**

added output redshifts derived from `gadget_timer.txt` as parameter `outputRedshifts` in .xml file

Random seeds that do not create cluster like structures at 32Mpc box: 589, 12170, 13610, 16604, 16749, 17362, 17433, 29666, 32223, 17595, 22045, 3724, 3183, 4152, 7581, 8502, 10153, 10657, 22946, 14841, 25060, 29468, 32634

Random seeds that look a little interesting: 15039 → rockstarred on AMD-03 (finished), 26214 → rockstarred on AMD-04

28.02.2012 Successfully started some N-GenIC jobs for comparison of IC generation

17.02.2012 Discussion with Asmus about Stages Cluster → try more systematic approach to ICs

15.02.2012 Galacticus revision 708 - `drd5_r256_2` not fixed → E-Mail to Andrew check tomorrow: Galacticus jobs `fuenfincr256_1` and `drdx_3_r256`

**Note: think about / find a good method for common metadata**

14.02.2012 Wrote E-Mail to Bertschinger.

13.02.2012 Deleted some jobs I started yesterday because they had artificial crosses or were practically unconstrained

Third simulation `fuenfincr256_1` ran through - Galacticus restart worked well!

**Note: IC with same seed but higher resolution do not yield the same simulation!** → started two more test runs from r128 sims to doublecheck

12.02.2012 Updated Galacticus to revision 707 as suggested by Andrew and added parameter `hotHaloOutflowAngularMomentumAlwaysGrows` to xml file.

Two of four simulations ran through (copied hdf5 to transfer), two crashed → try to continue at saved states!

10.02.2012 wrote E-Mail to Andrew about performance problems and wavelenght computation error in `fuenfincr256_1`

started some runs with higher central delta and broader smoothing lenghts, i.e. 32/dx and 100/dx; all 128 resolution except second last one (same seed!):

83492	0.60500	d31c_1_st	harre	r	02/10/2012	15:19:56	astro18	16
83493	0.60500	d31c_2_st	harre	r	02/10/2012	15:20:37	astro29	16
83494	0.60500	d31c_3_st	harre	r	02/10/2012	15:21:17	astro25	16
83495	0.60500	d51c_s1100	harre	r	02/10/2012	15:23:21	astro31	16
83496	0.54786	d3+3c_s150	harre	r	02/10/2012	15:37:13	astro12	16
83497	0.60500	d3+3c_s150	harre	r	02/10/2012	15:39:16	astro30	32
83498	0.60500	d15+3c_s15	harre	r	02/10/2012	15:44:23	astro30	16

09.02.2012 `drd5_r256` last written to hdf5 file feb 09, 05:07

`fuenfincr256_2` last written to hdf5 file feb 06, 03:28

`drd5_r256_2` last written to hdf5 file feb 07, 00:50

02.02.2012 drdx\_h100\_128\_1 run has again severe consistency metric problem  
→ not clear why  
upper python script does not work, was commented out again  
plan: **move to python scripts in general in order to have easier arithmetic calculations**  
plan: create new folder structure and remove old simulations → done

31.01.2012 note: h=70.3 in galacticus xml input file is expected, consistent tree obviously implies it  
→ fixed: changed in markus parameter file for the converter and in xml file  
→ question: why not read out?  
→ python updateGalacticusStart.py from Markus

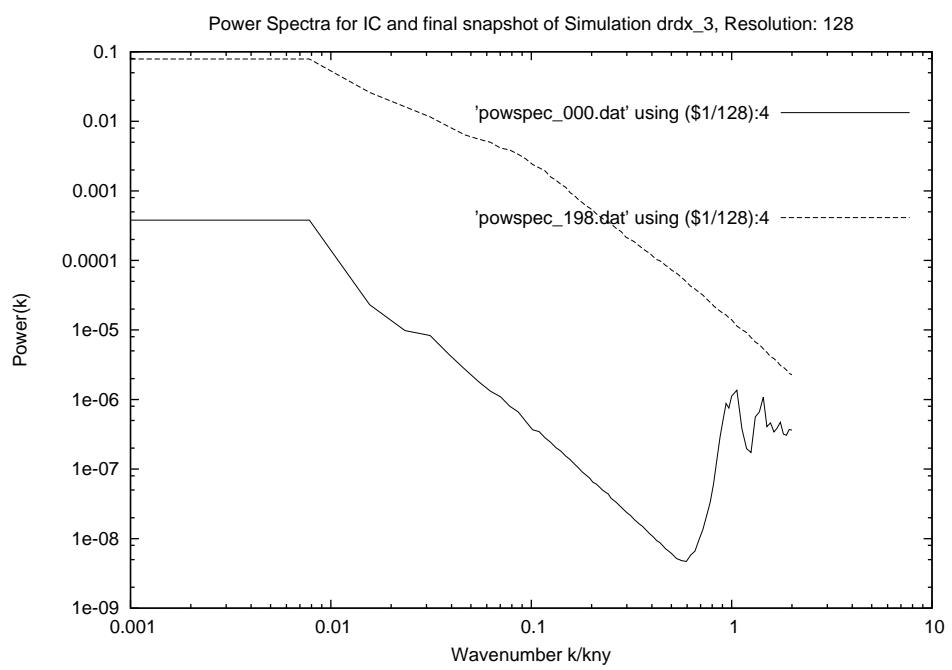
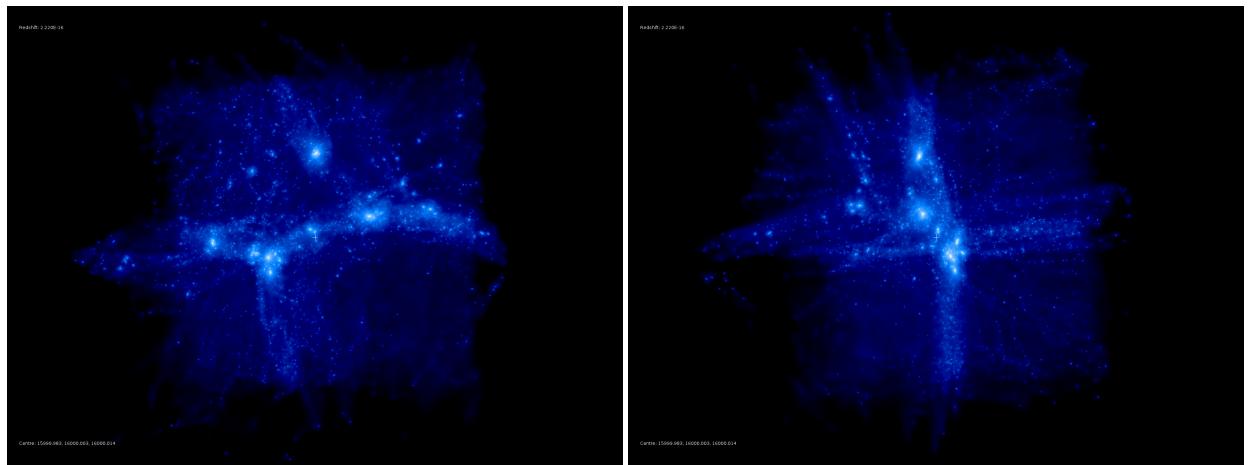
30.01.2012 new consistenttree with vmax=20

# Chapter 2

## Simulations

### 2.1 r128

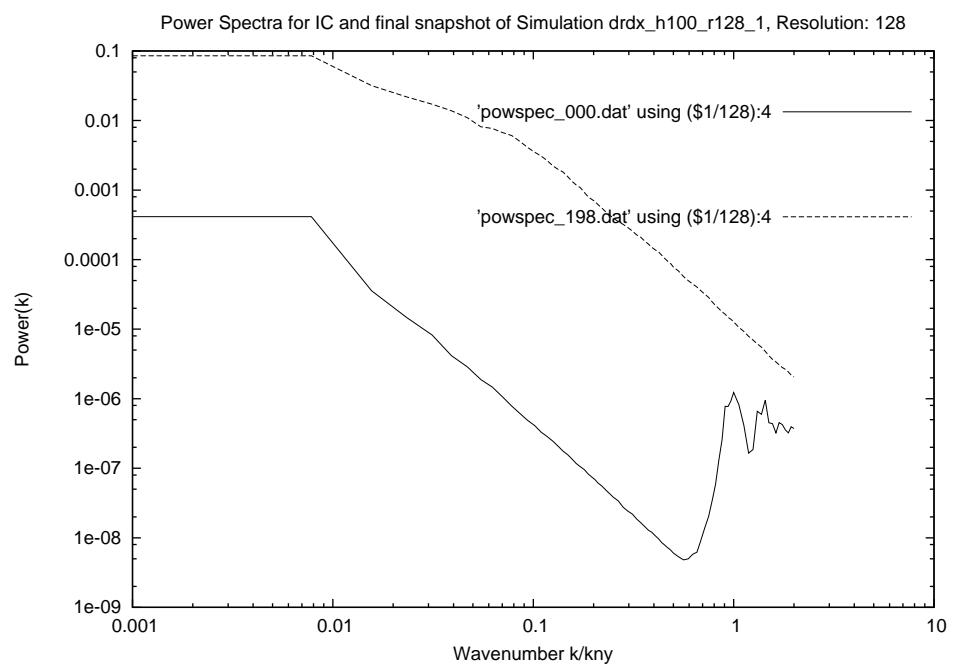
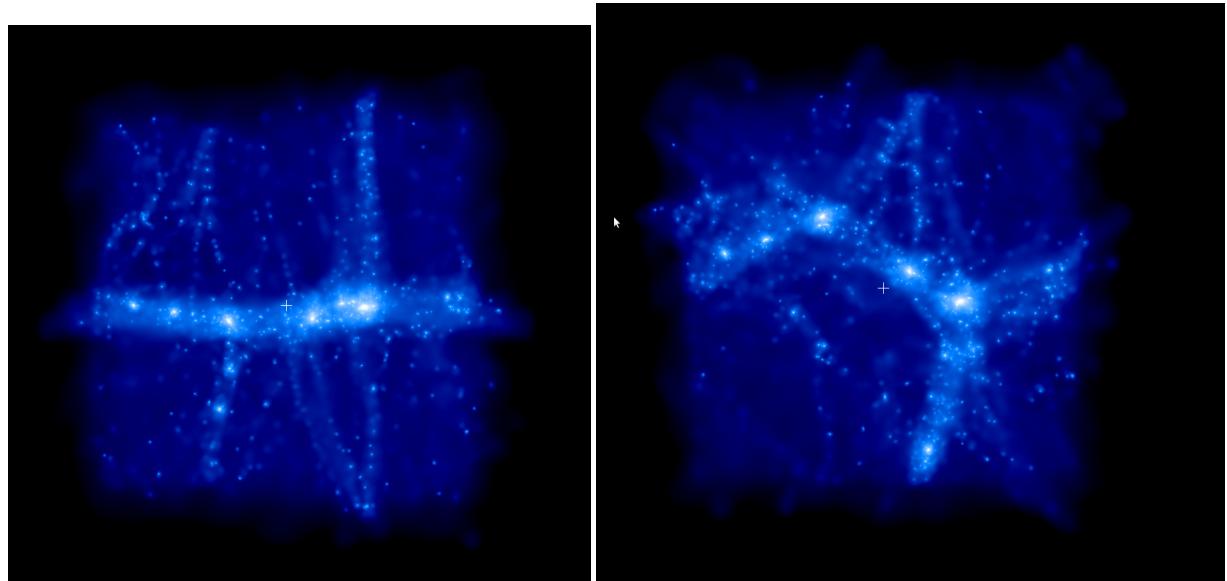
#### 2.1.1 drdx\_3



ROCKSTARRED ✓

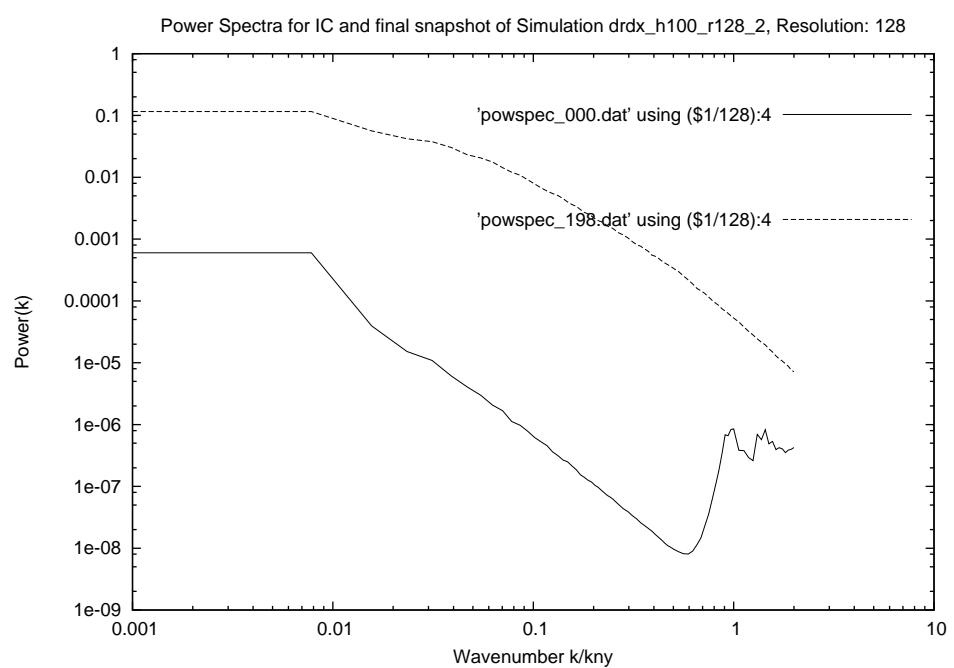
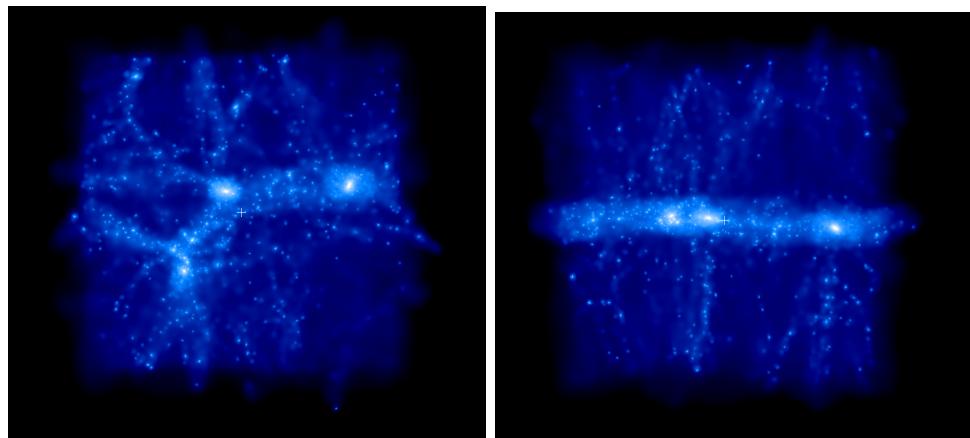
pfff → Error: too few halos at scale factor 0.926072 to calculate consistency metric.

### 2.1.2 drdx\_h100\_r128\_1

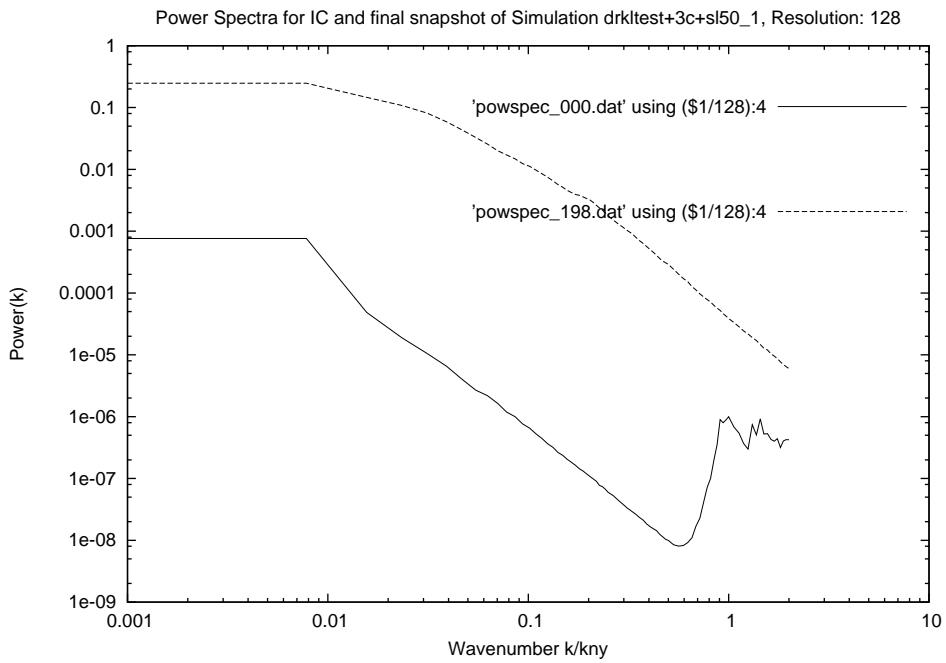


ROCKSTARRED ✓  
 consistenttree: too few halos at scale factor 0.896 ... → wtf?

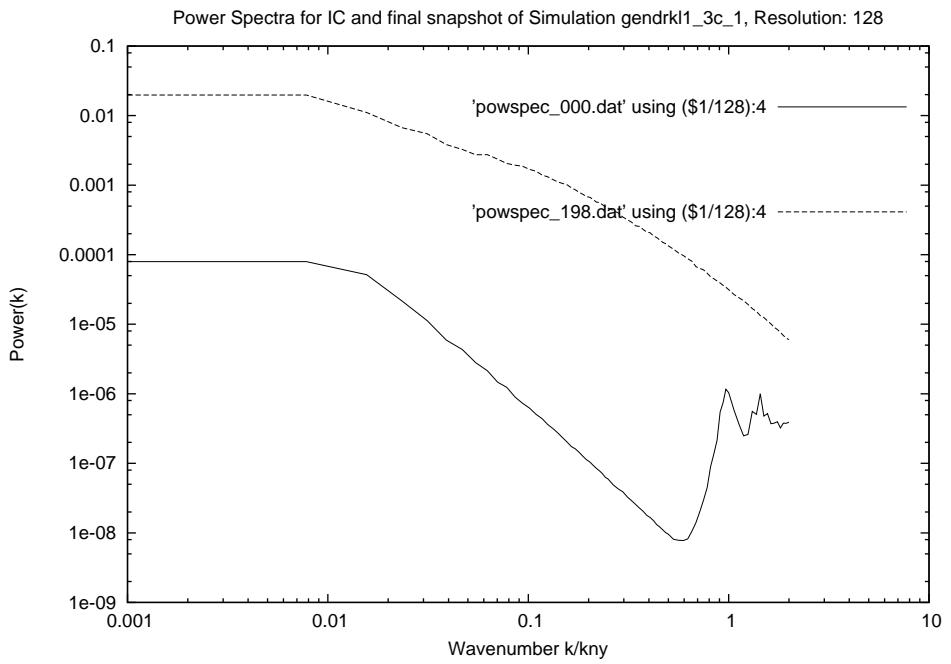
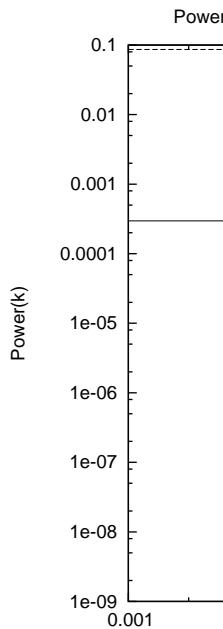
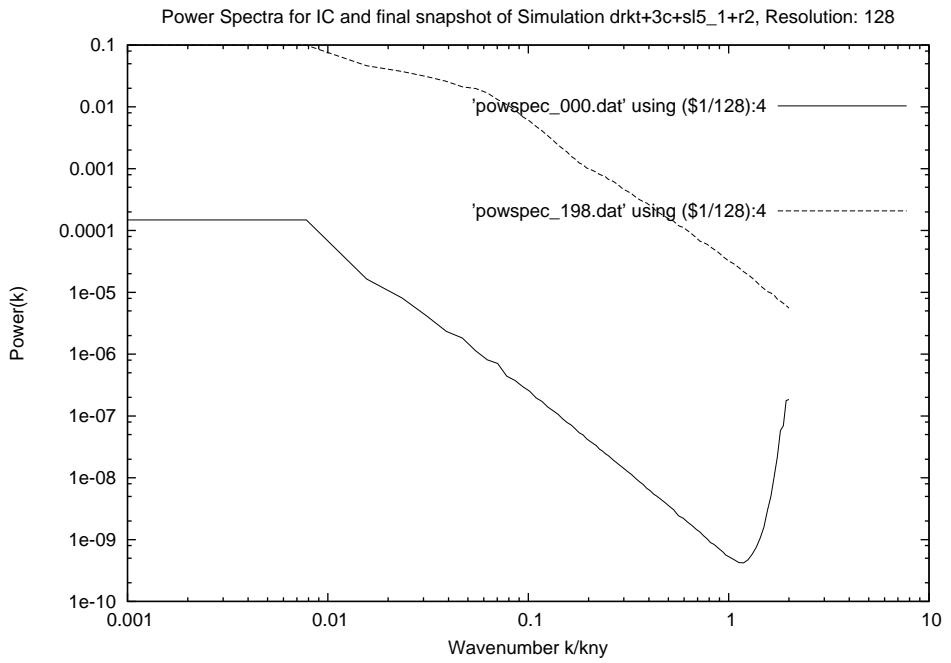
### 2.1.3 drdx\_h100\_r128\_2



### 2.1.4 drkltest+3c+sl50\_1

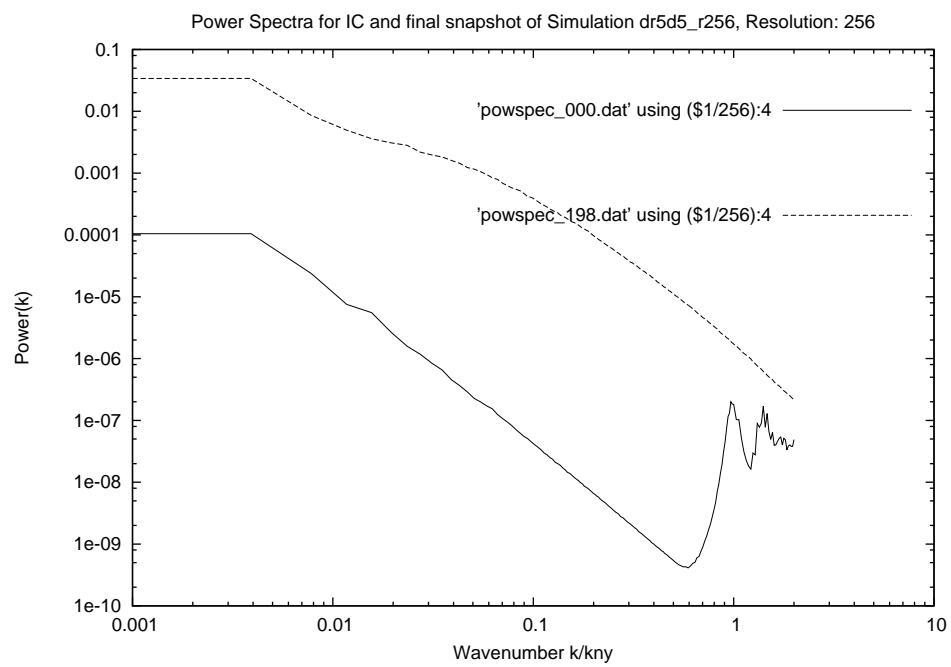
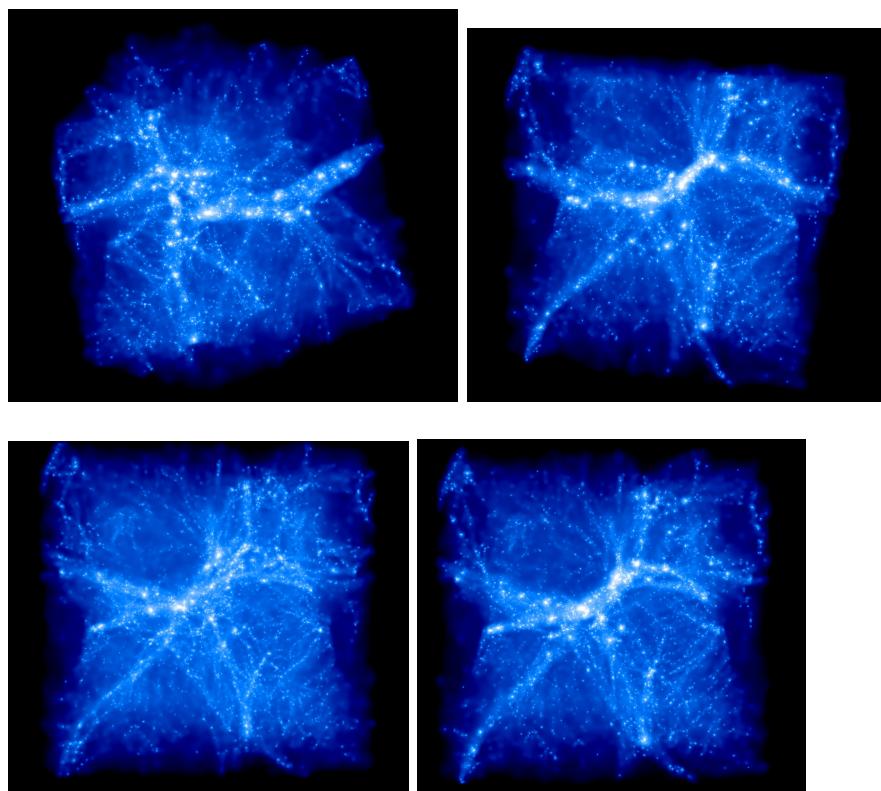


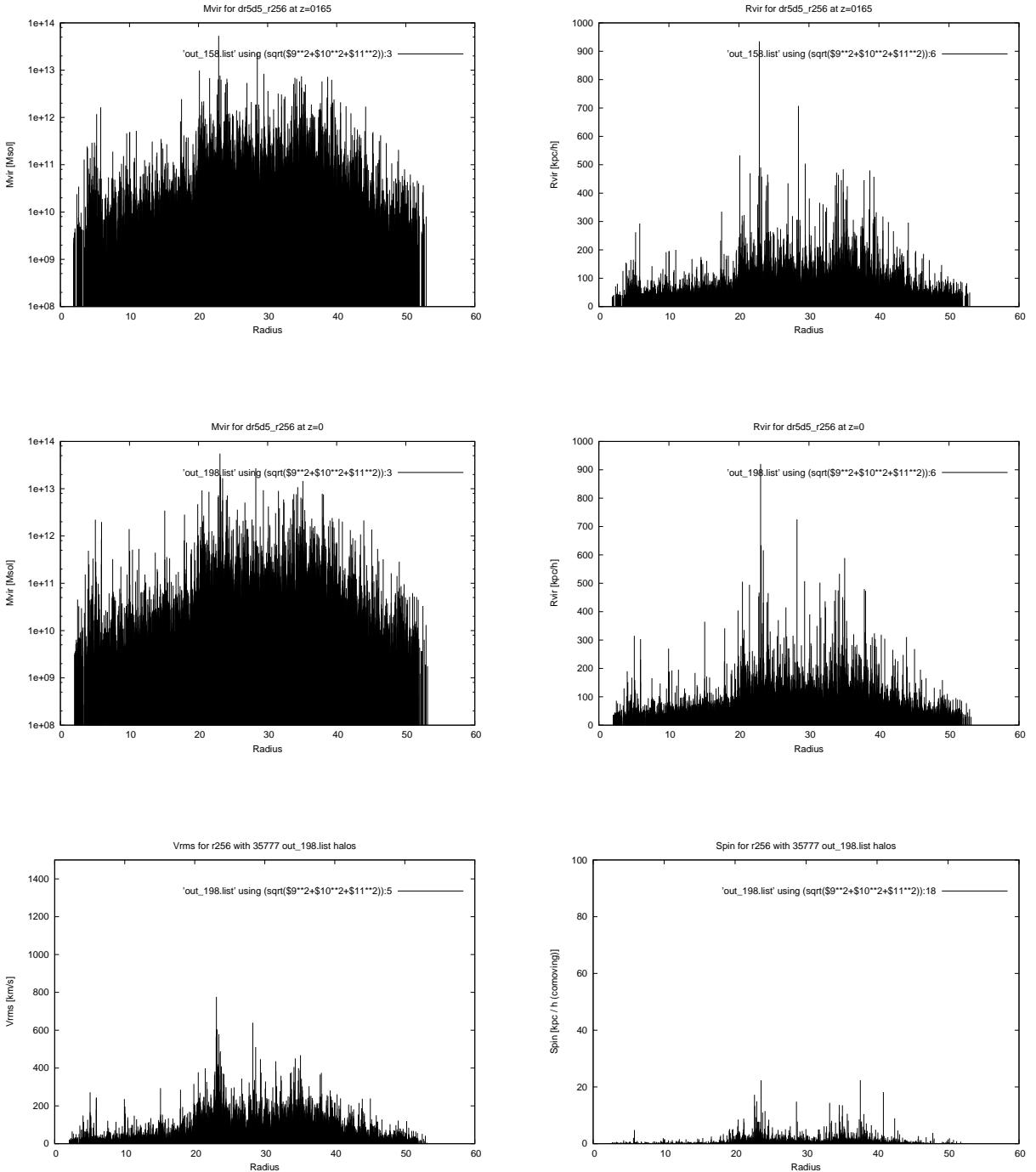
Error: too few halos at scale factor 0.890265 to calculate consistency metric.  
Please remove this and all earlier timesteps from the scale file and rerun.  
(DescScales.txt)



## 2.2 r256

### 2.2.1 dr5d5\_r256





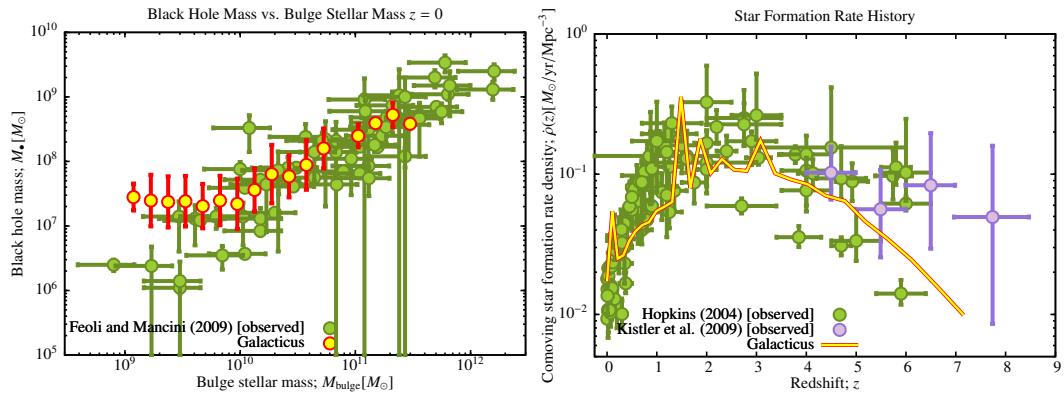
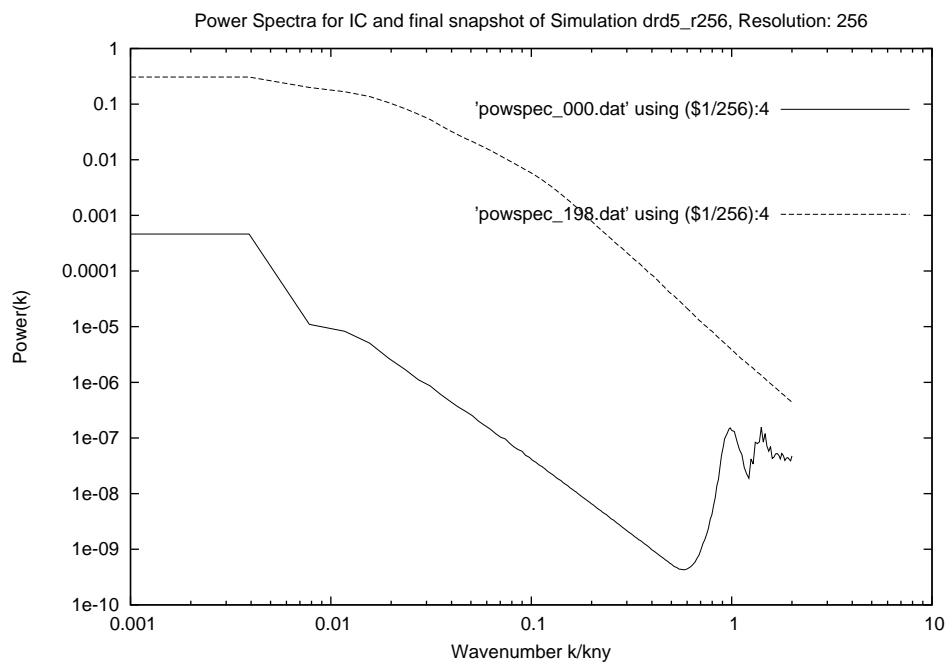
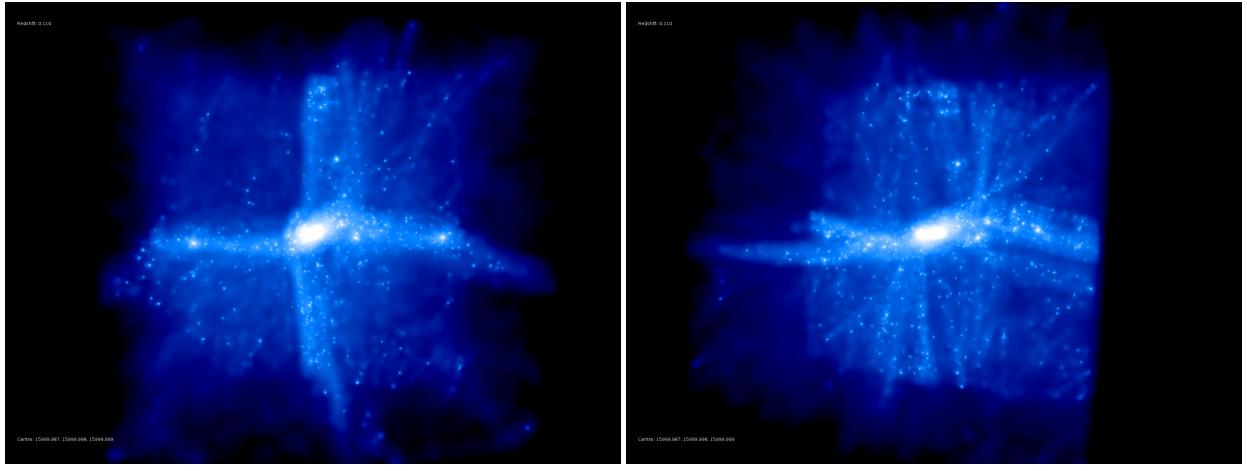
is being galacticussed  
 CONSISTENTTREED ✓  
 ROCKSTARRED ✓  
 → re-rockstar on AMD ...-03

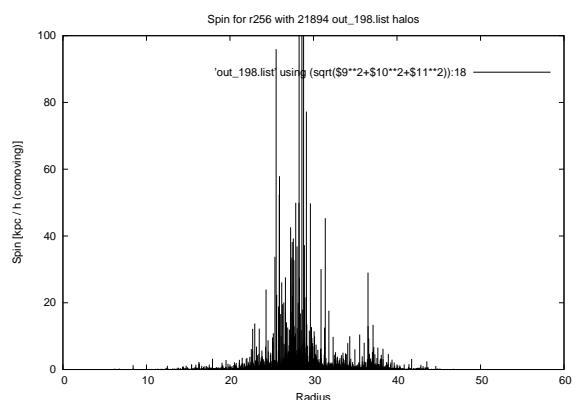
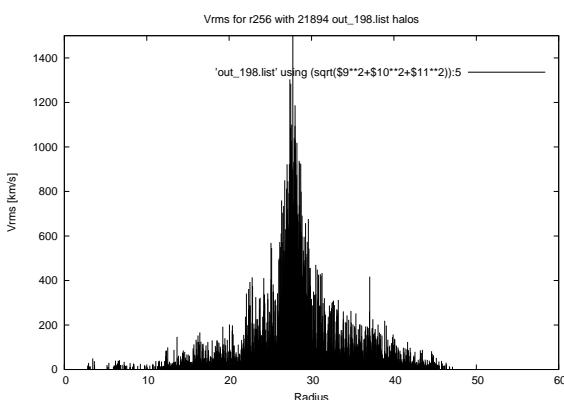
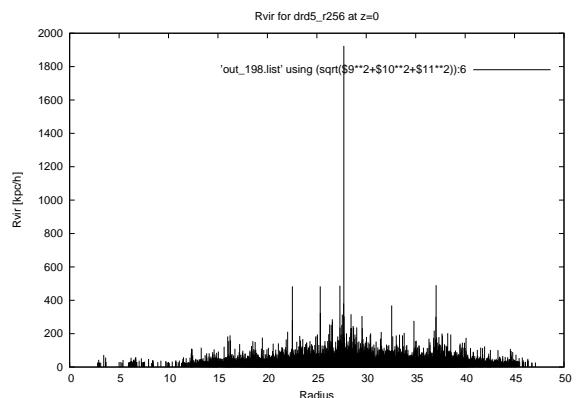
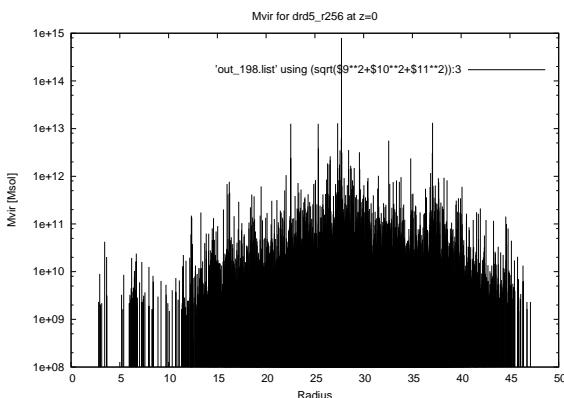
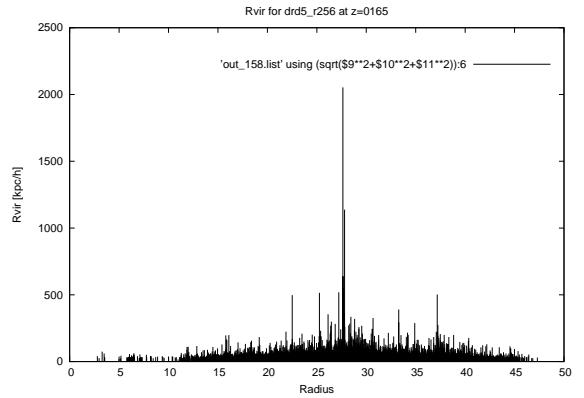
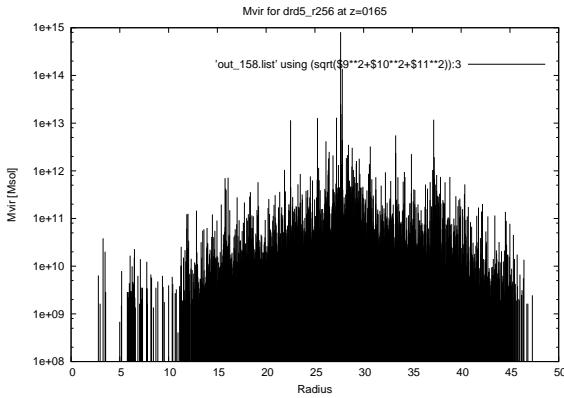
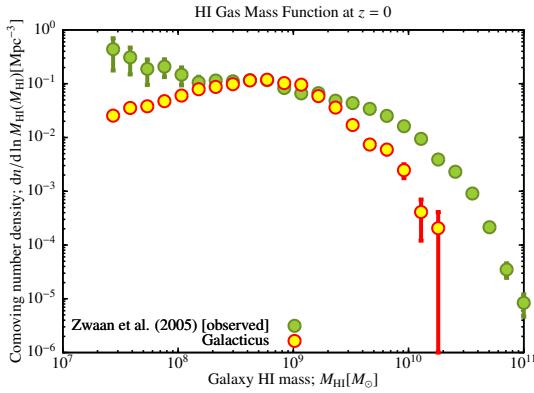
```
find_parents_and_cleanup.c:130:  

lookup_new_id: Assertion `new_id' failed.
```

is being consistentreed

### 2.2.2 drd5\_r256 ( $\sim$ )





GALACTICUSSED ✓

galacticus running on SGE

→ re-converted with bugfixed converter

tree copied to markus transfer

GALACTICUS:

```
Fatal error in Build_Descendent\_Pointers():
```

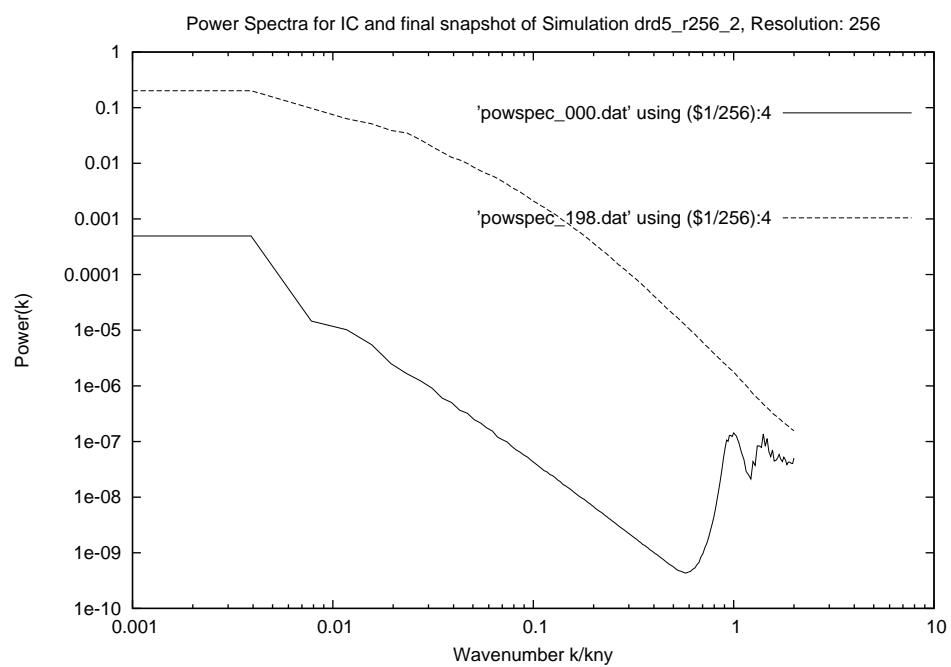
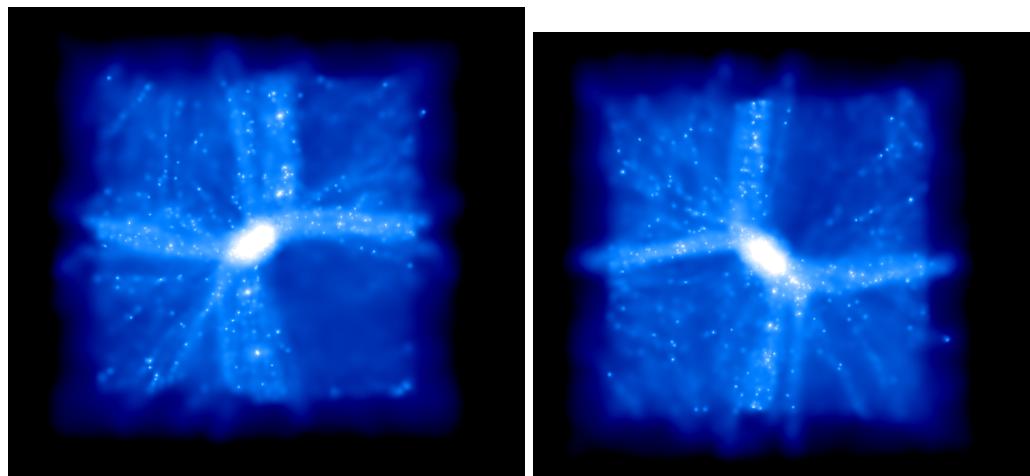
```
failed to find descendant node: 5546454 of 5522259
```

```
galacticus.sh: line 67: 25689 Aborted
```

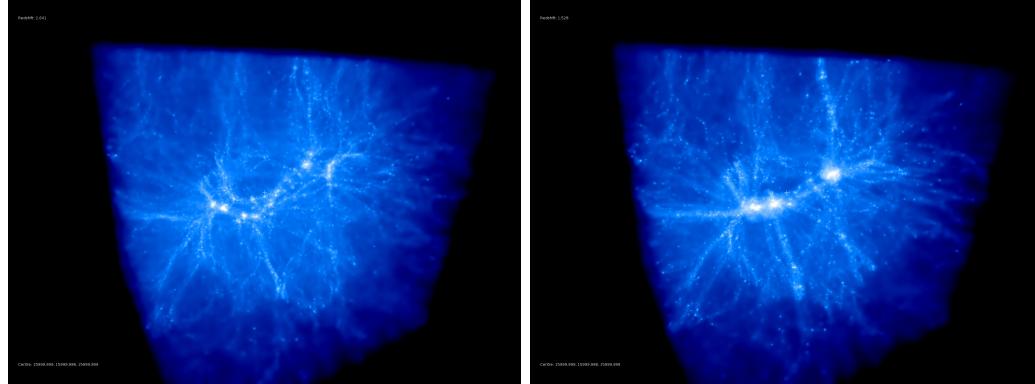
CONSISTENTTREEED ✓

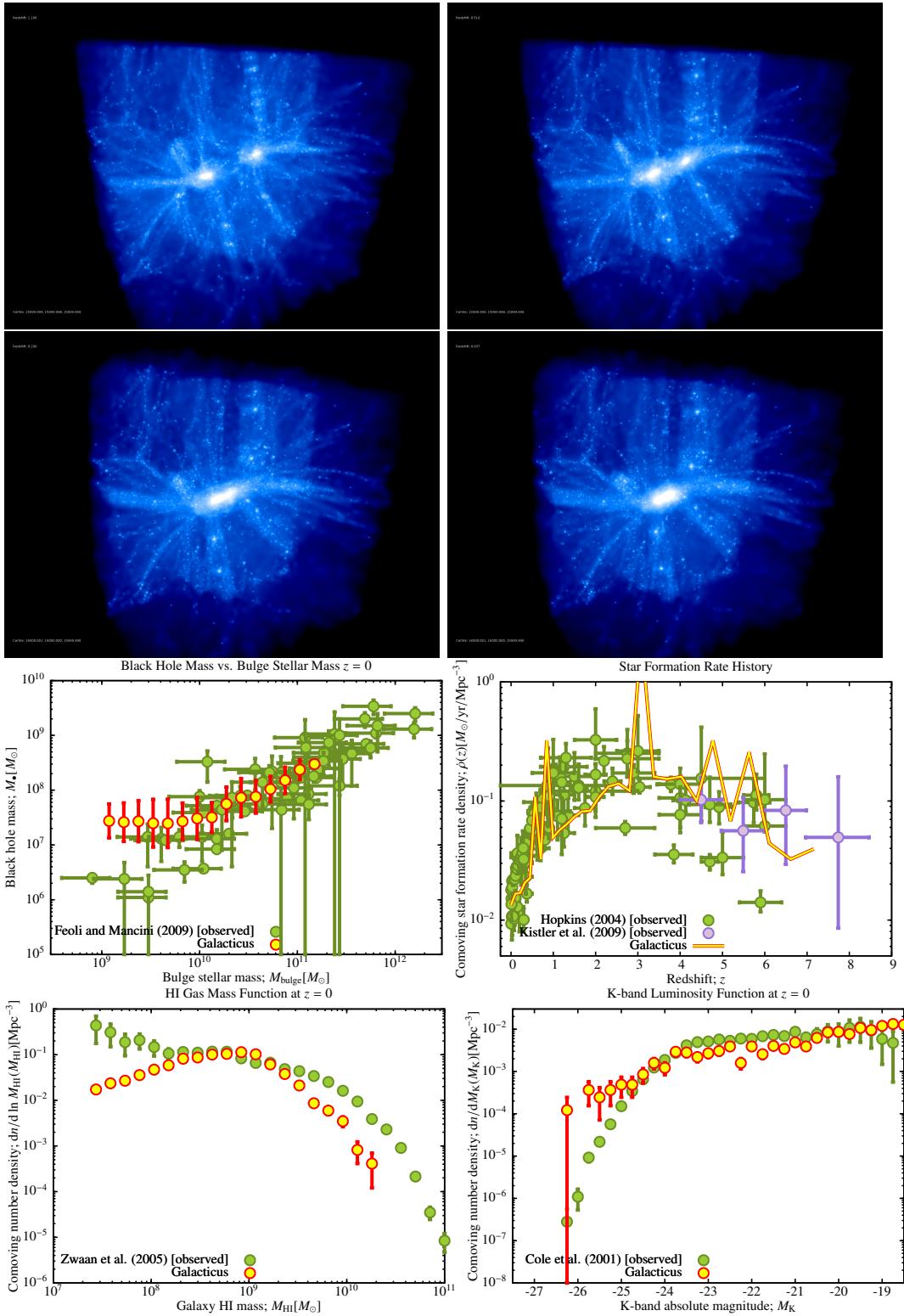
ROCKSTARRED ✓

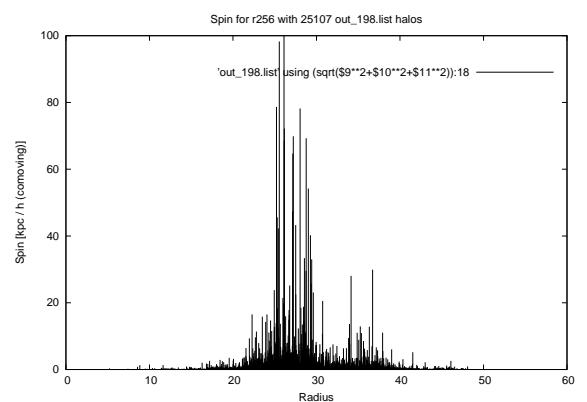
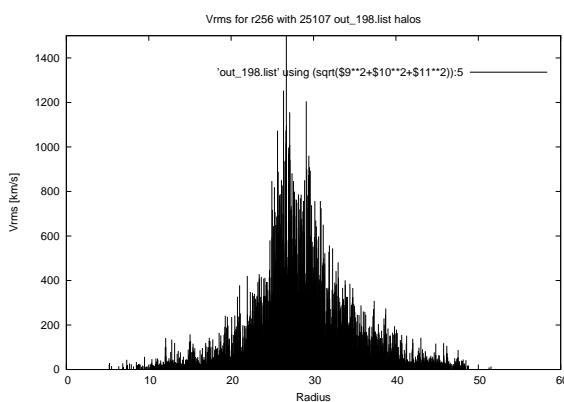
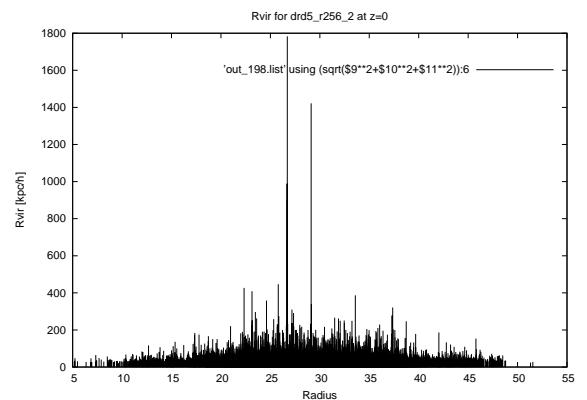
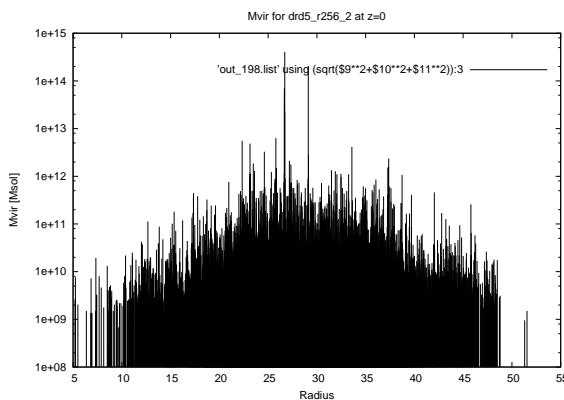
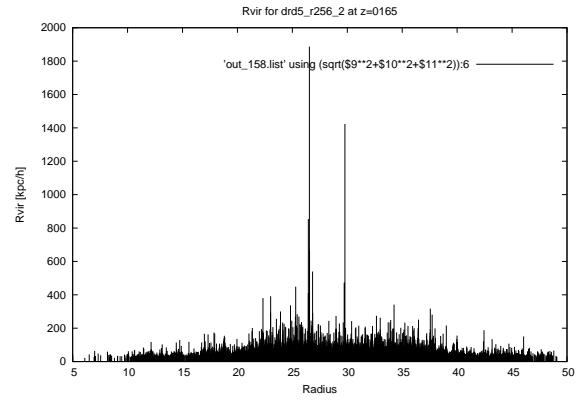
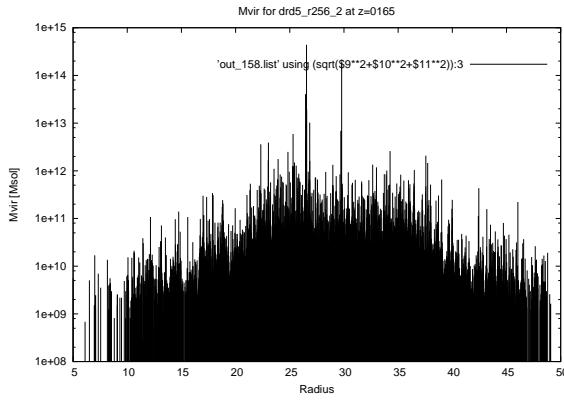
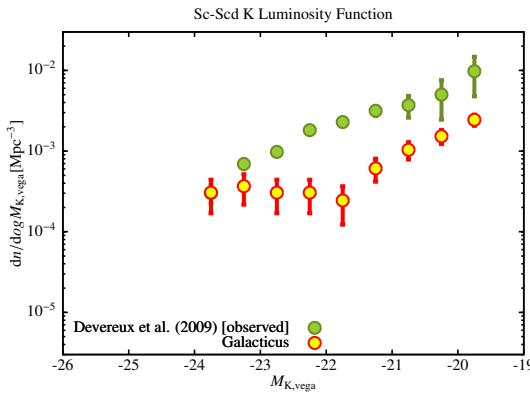
### 2.2.3 drd5\_r256\_2 (+ major merger in progress)



#### Evolution:







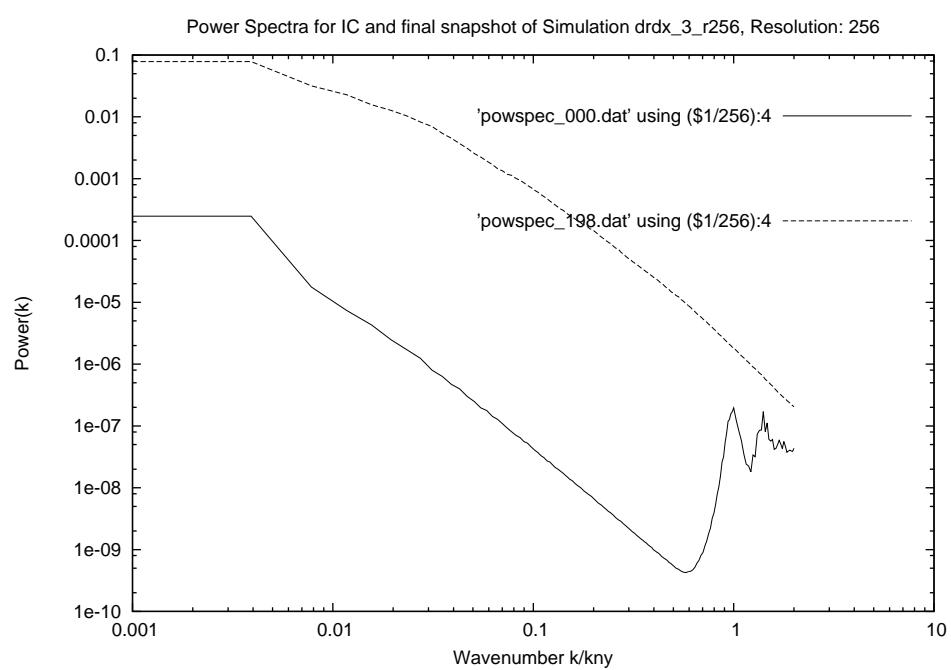
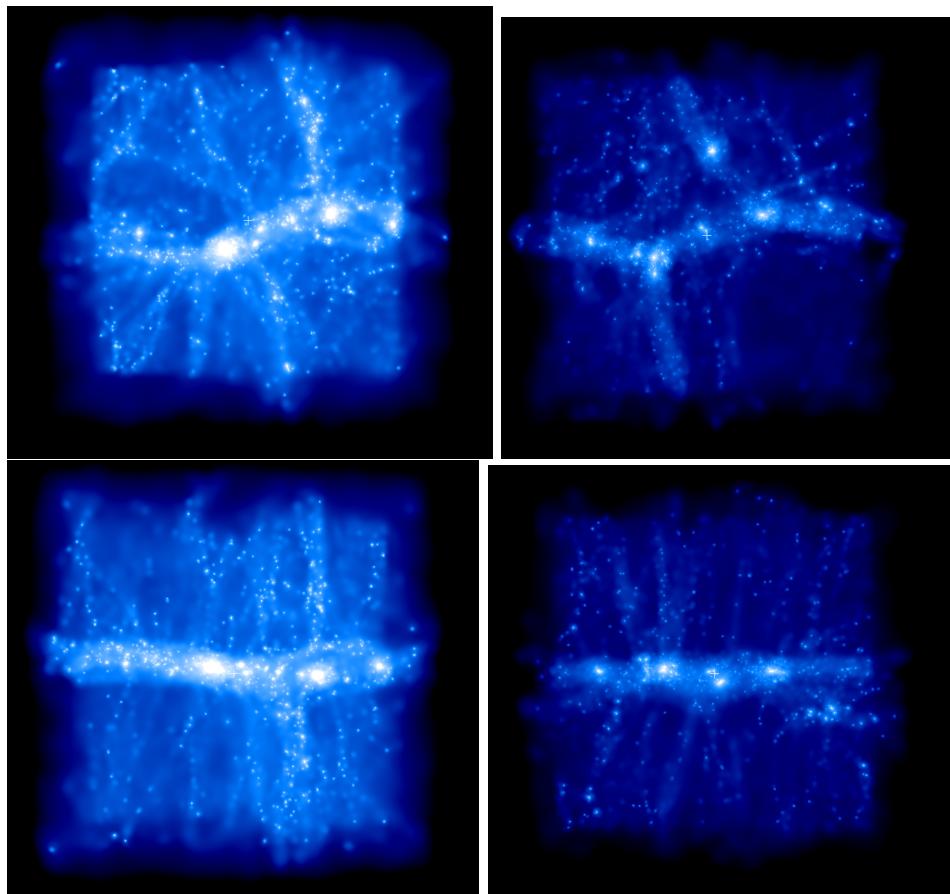
GALACTICUSSED ✓  
→ fixed in revision 709  
→ not fixed! E-Mail to Andrew  
After fix in rev. 708 → is being re-galacticussed  
→ DUMP IT ?  
→ gadgetviewer: simulation has "artificial" cross galacticus running on SGE  
→ re-converted with bugfixed converter (v0.3)  
is being galacticussed → job seems to run!

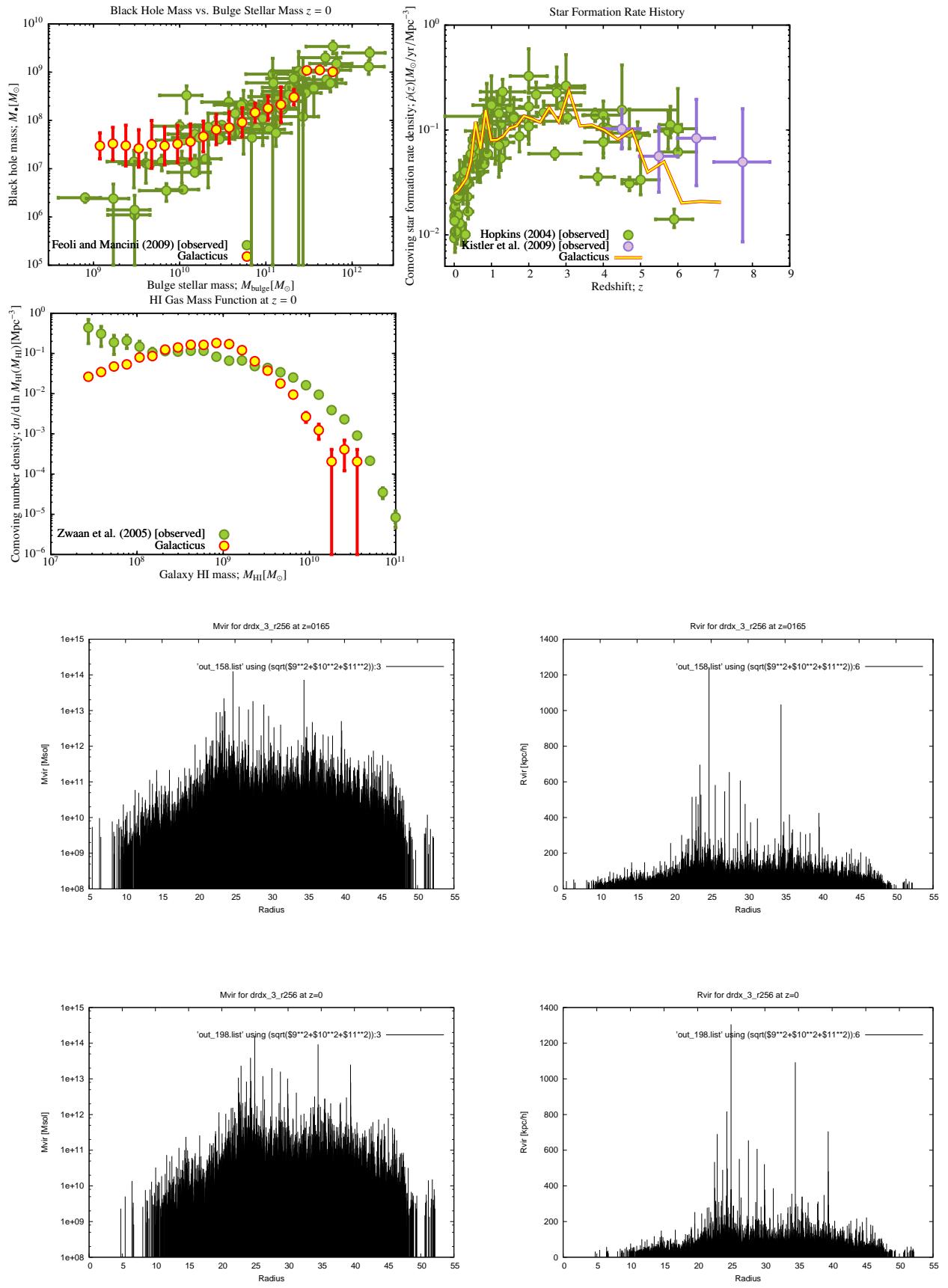
```
no: A fatal error occurred! Backtrace for this error:  
#0 0x2B3F2E65E897  
#1 0x2B3F2E65EE4E  
#2 0x301763648F  
#3 0x487AA0 in __merger_tree_read_MOD_build_descendent_pointers  
#4 0x48ADC3 in __merger_tree_read_MOD_merger_tree_read_do  
#5 0x48205E in __merger_tree_construction_MOD_merger_tree_create  
#6 0x46F469 in __galacticus_tasks_evolve_tree_MOD_galacticus_task_evolve_tree._omp_fn.0  
.F90:0  
#7 0x46F9C4 in __galacticus_tasks_evolve_tree_MOD_galacticus_task_evolve_tree  
#8 0x46FA4F in __galacticus_tasks_MOD_galacticus_task_do  
#9 0x4600E4 in MAIN__ at Galacticus.F90:0
```

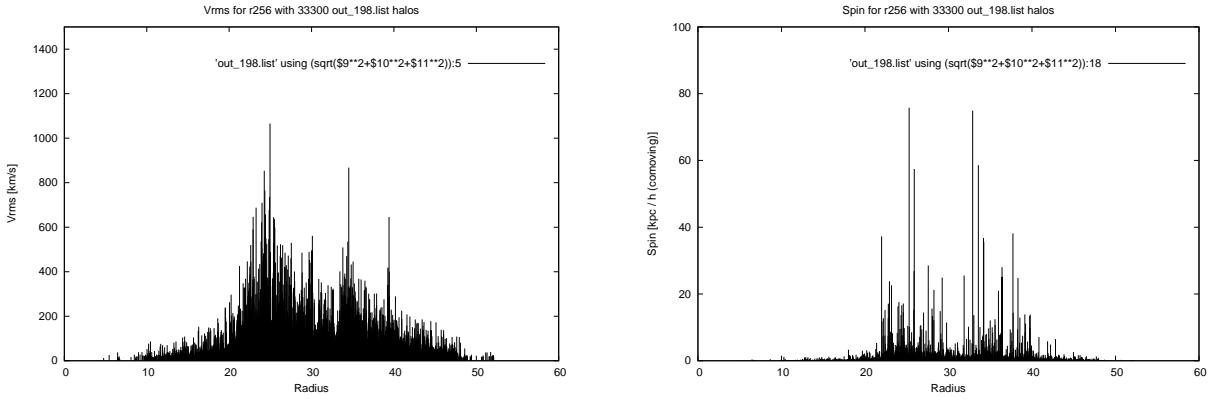
CONSISTENTTREEED ✓

ROCKSTARRED ✓ (lasted about 9000minutes)

### 2.2.4 drdx\_3\_r256







GALACTICUSSED ✓  
 → fixed in revision 709

GALACTICUS REV708:

```
#4 0x301763648F
#5 0x49B1B8 in __merger_tree_read_MOD_build_descendent_pointers at merger_trees.construct
#6 0x49FF70 in __merger_tree_read_MOD_merger_tree_read_do at merger_trees.construct.read
#7 0x4923BE in __merger_tree_construction_MOD_merger_tree_create at merger_trees.constr
#8 0x4800C6 in __galacticus_tasks_evolve_tree_MOD_galacticus_task_evolve_tree._omp_fn.0
#9 0x2AC099B4F829
#10 0x3017A07CD0
#11 0x30176DFD3C
#12 0xFFFFFFFFFFFFFF
/sge-root/sge/AMD64/spool/astro13/job_scripts/83594: line 22: 13318 Aborted
```

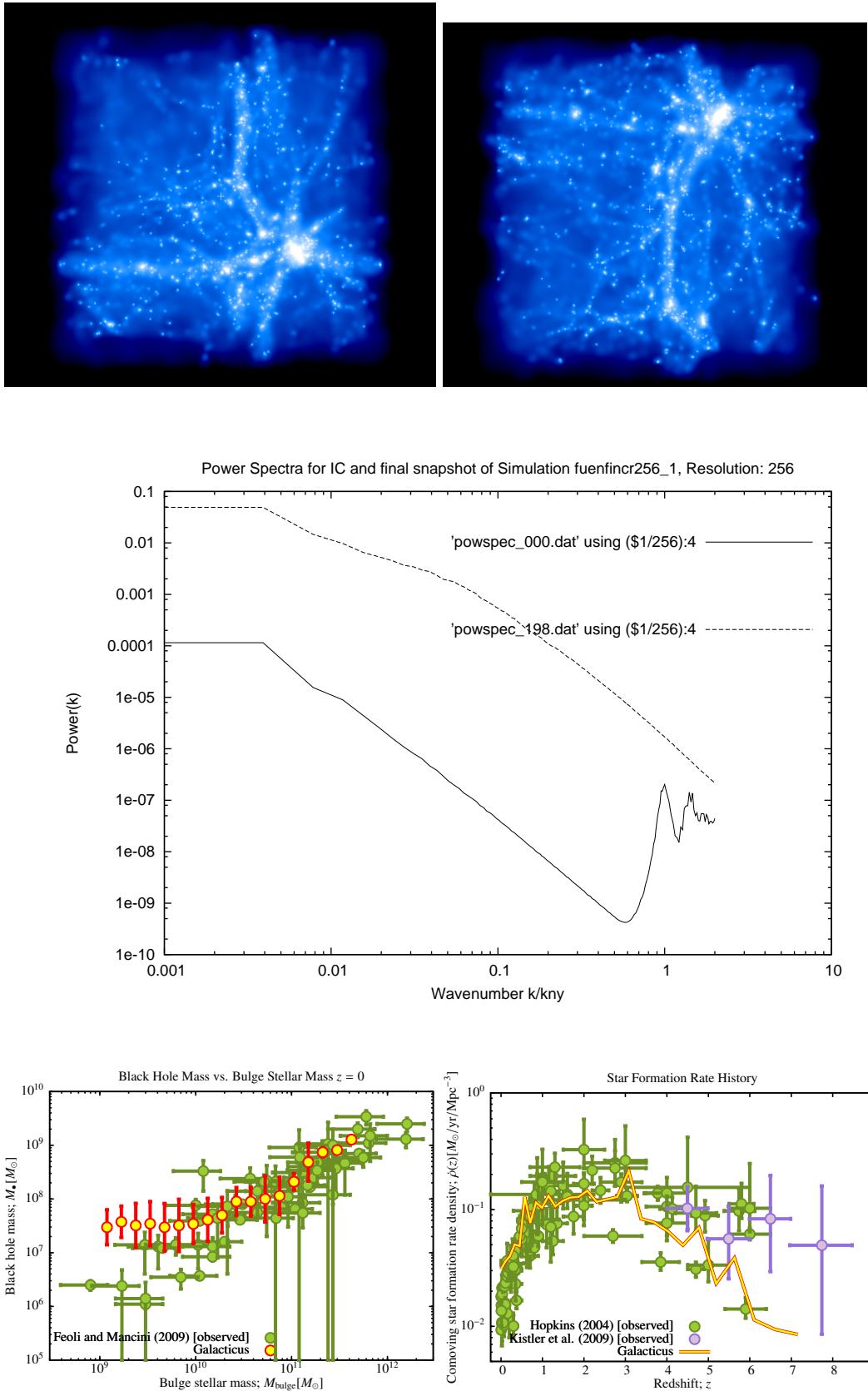
CONSISTENTTREEED ✓

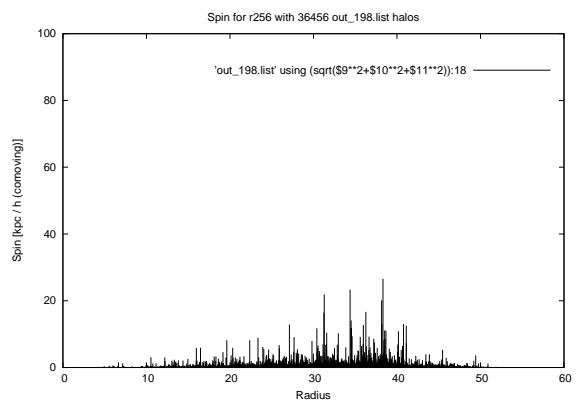
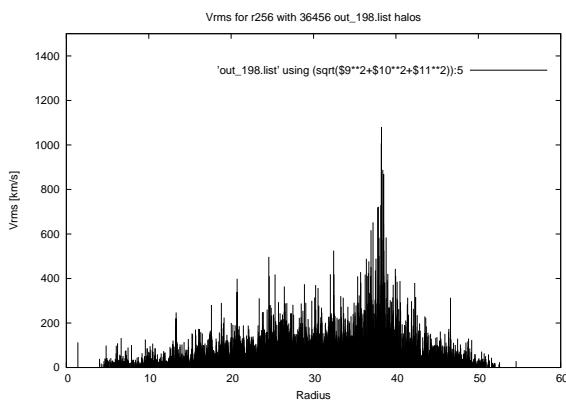
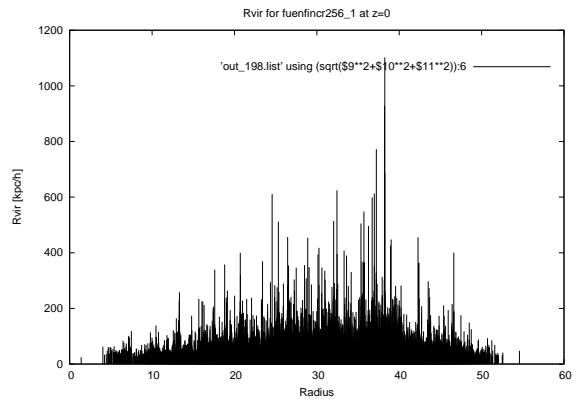
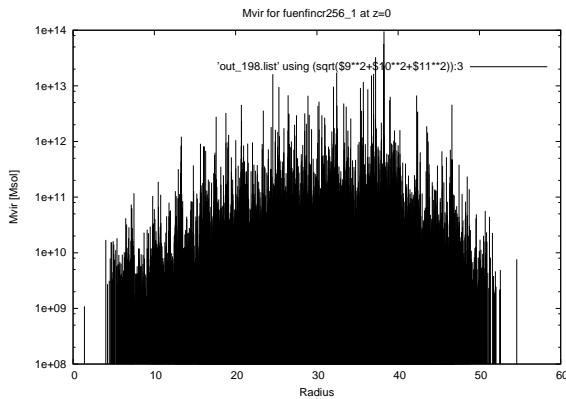
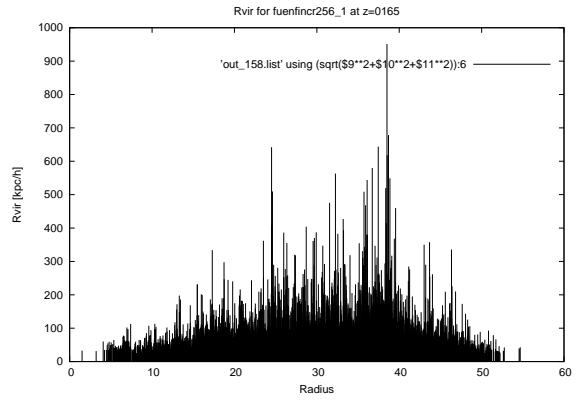
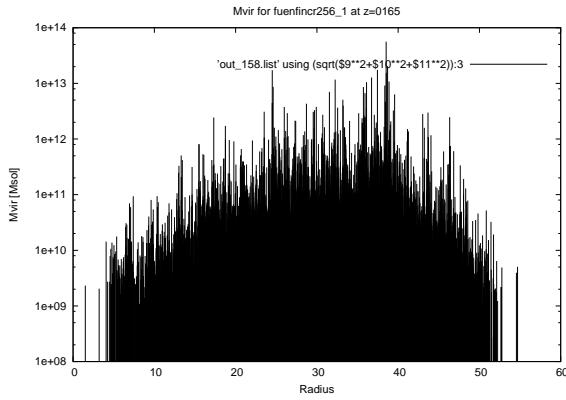
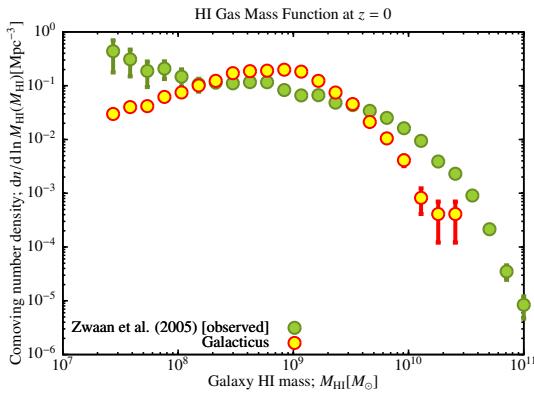
ROCKSTARRED ✓

is being rockstarred on astro-x4600-03

This run is a test if r256 and r128 (drdx\_3) are comparable → see pictures.

### 2.2.5 fuenfincr256\_1





GALACTICUSSED √

→ re-galacticussing with rev708

GALACTICUS: rev707 exited without error but not finished

GALACTICUSSED √ BUT:

[3:46:48 PM CEST] Markus Haider: der fuenfincr256\_1 hat a problem

[3:46:52 PM CEST] Markus Haider: der hat keine output gruppe

[3:46:58 PM CEST] Markus Haider: also keinen output

[3:47:30 PM CEST] Markus Haider: btw schon einen output

[3:47:34 PM CEST] Markus Haider: aber es scheint was zu fehlen

→ E-Mail to Andrew

→ re-converted with bugfixed converter

Running model.....

Reading data for metallicity log10(Z/Z\_Solar) = 0.198

Found 188 ages in the file

Found 1963 wavelengths in the file

gsl: ../../roots/brent.c:57: ERROR: function value is not finite

Default GSL error handler invoked.

tree copied to markus transfer

GALACTICUS:

Fatal error in Build\_Descendent\_Pointers():

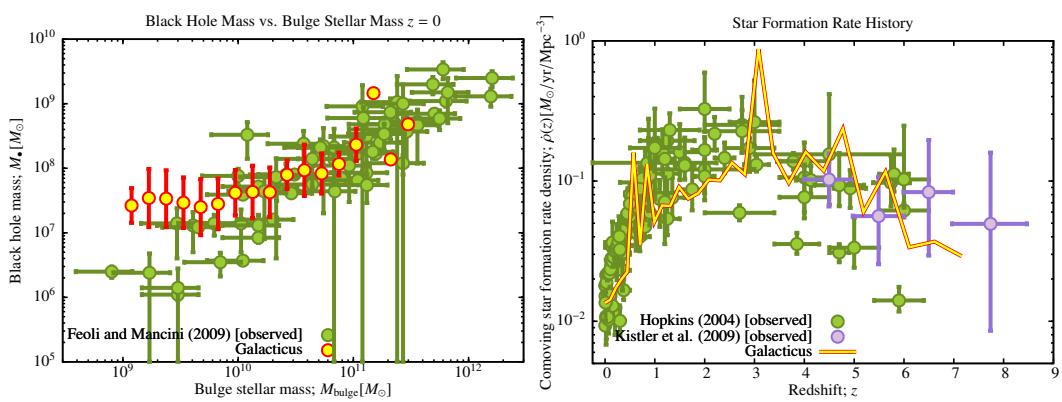
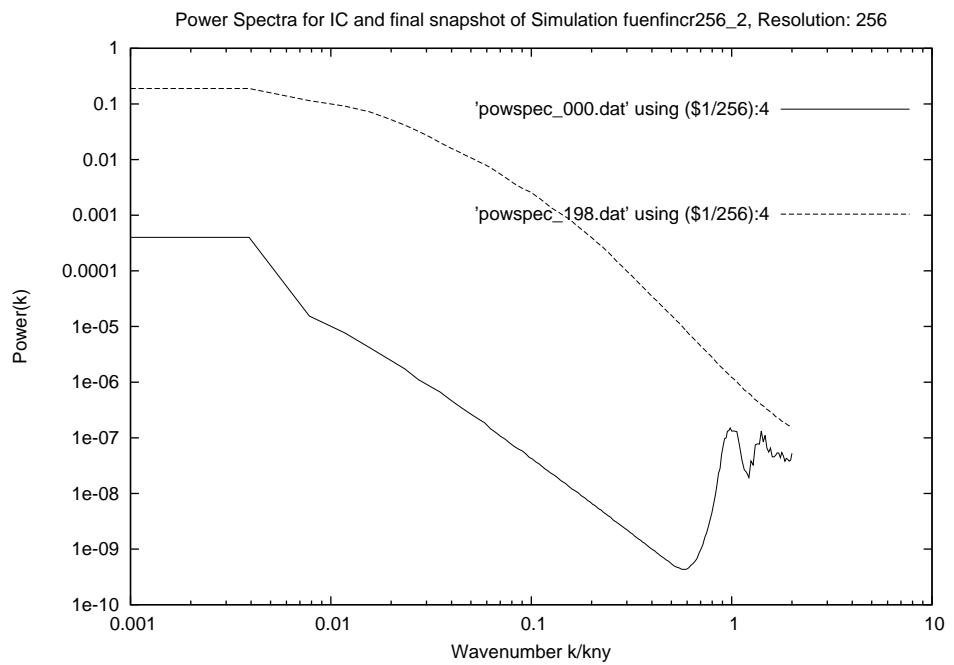
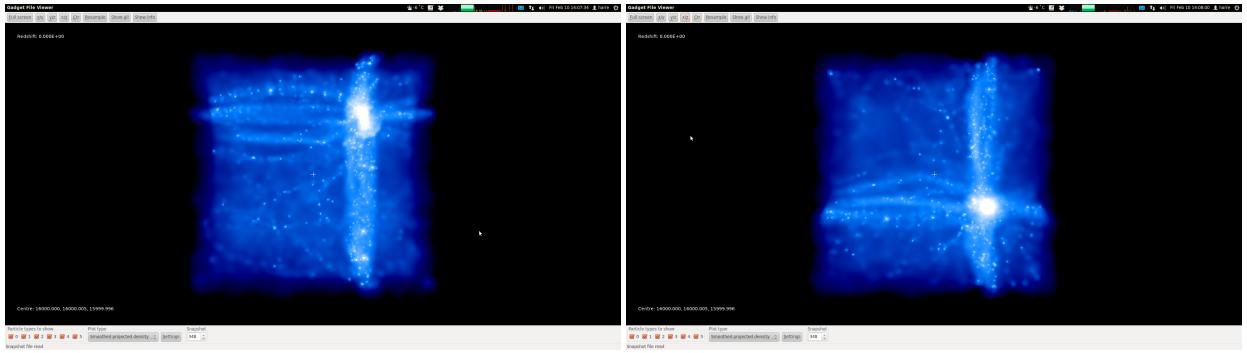
failed to find descendent node: 12048576 of 12014628

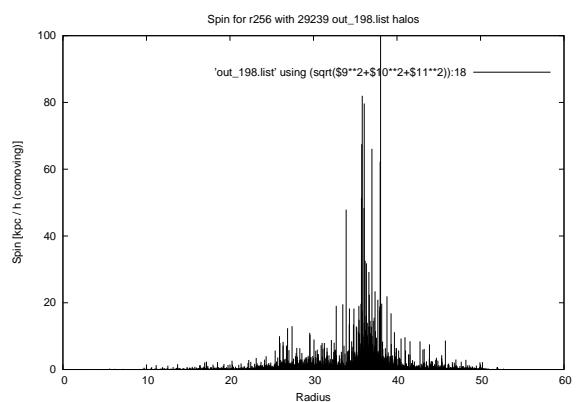
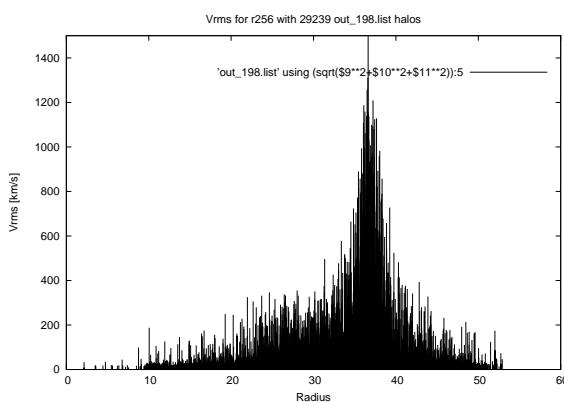
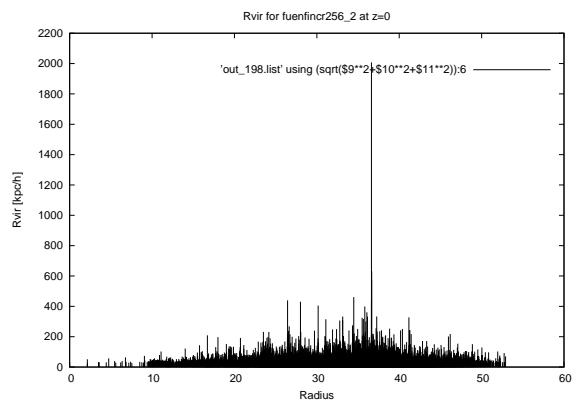
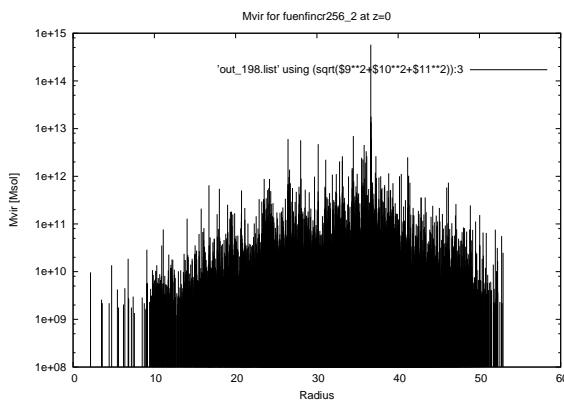
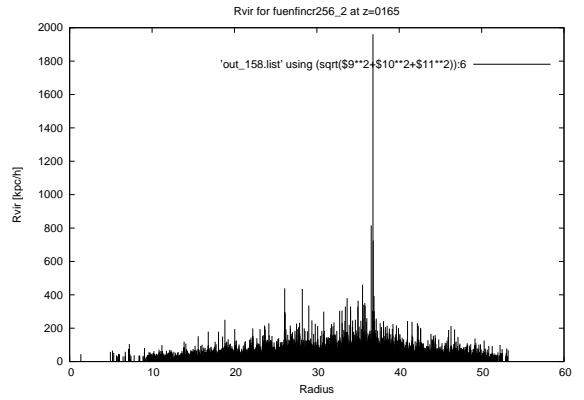
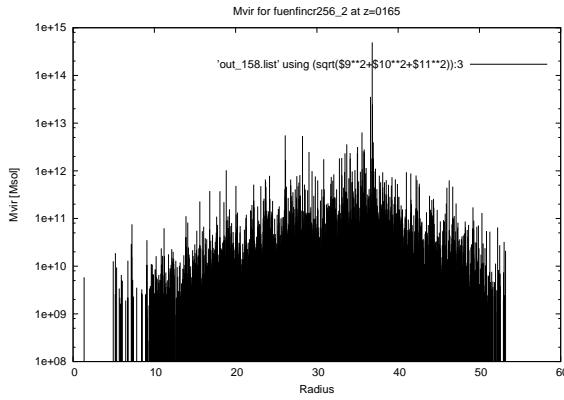
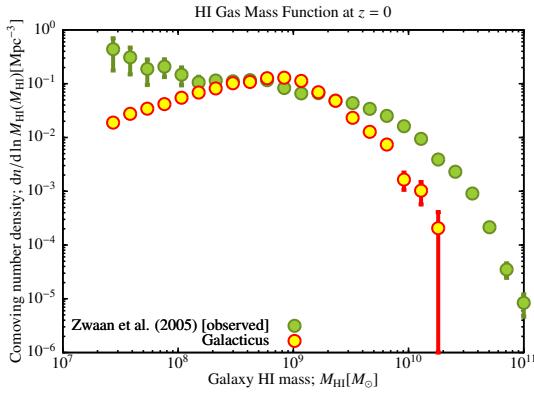
galacticus.sh: line 67: 5751 Aborted

ROCKSTARRED √

CONSISTENTTREED √

### 2.2.6 fuenfincr256\_2 → dump!



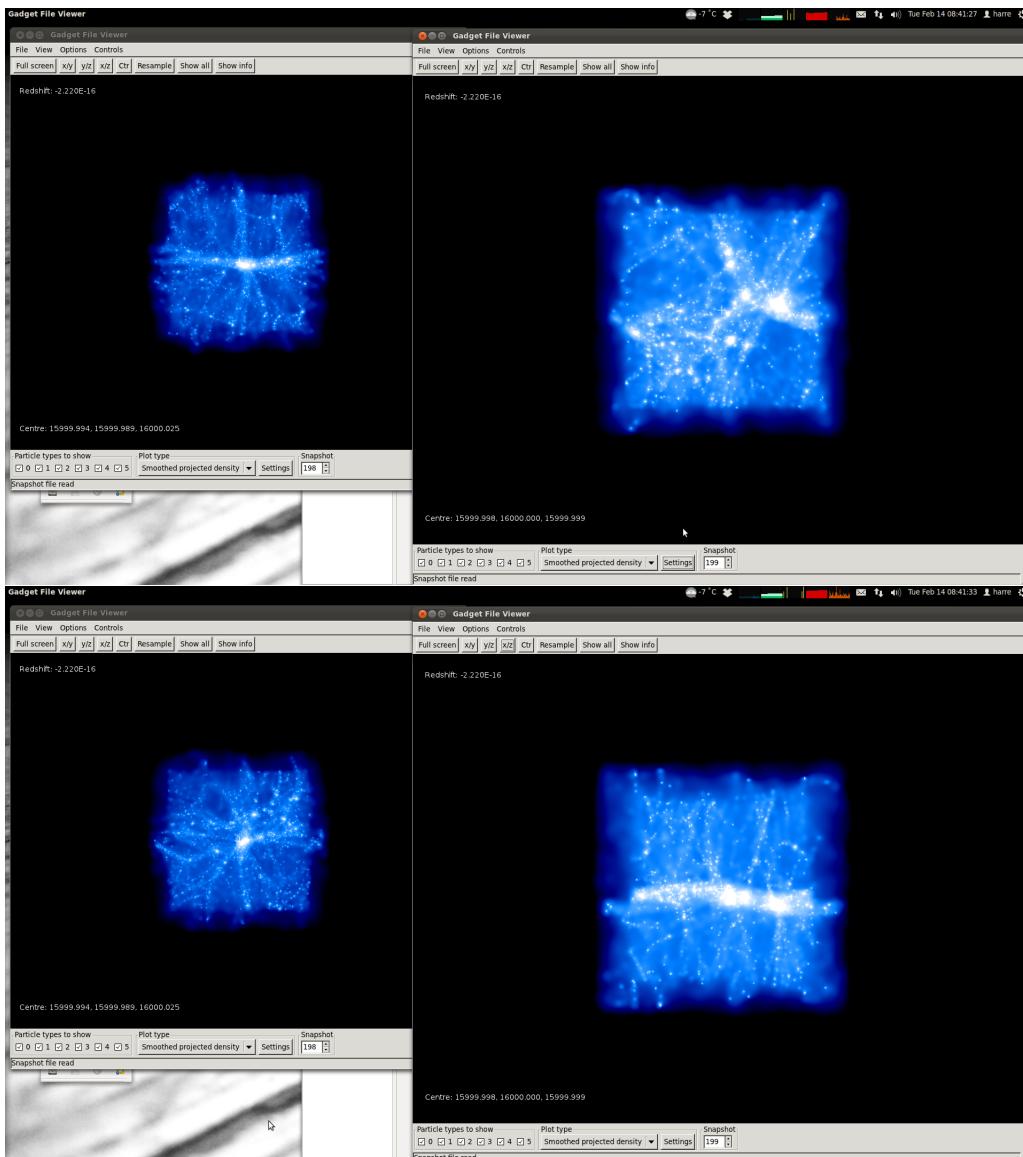


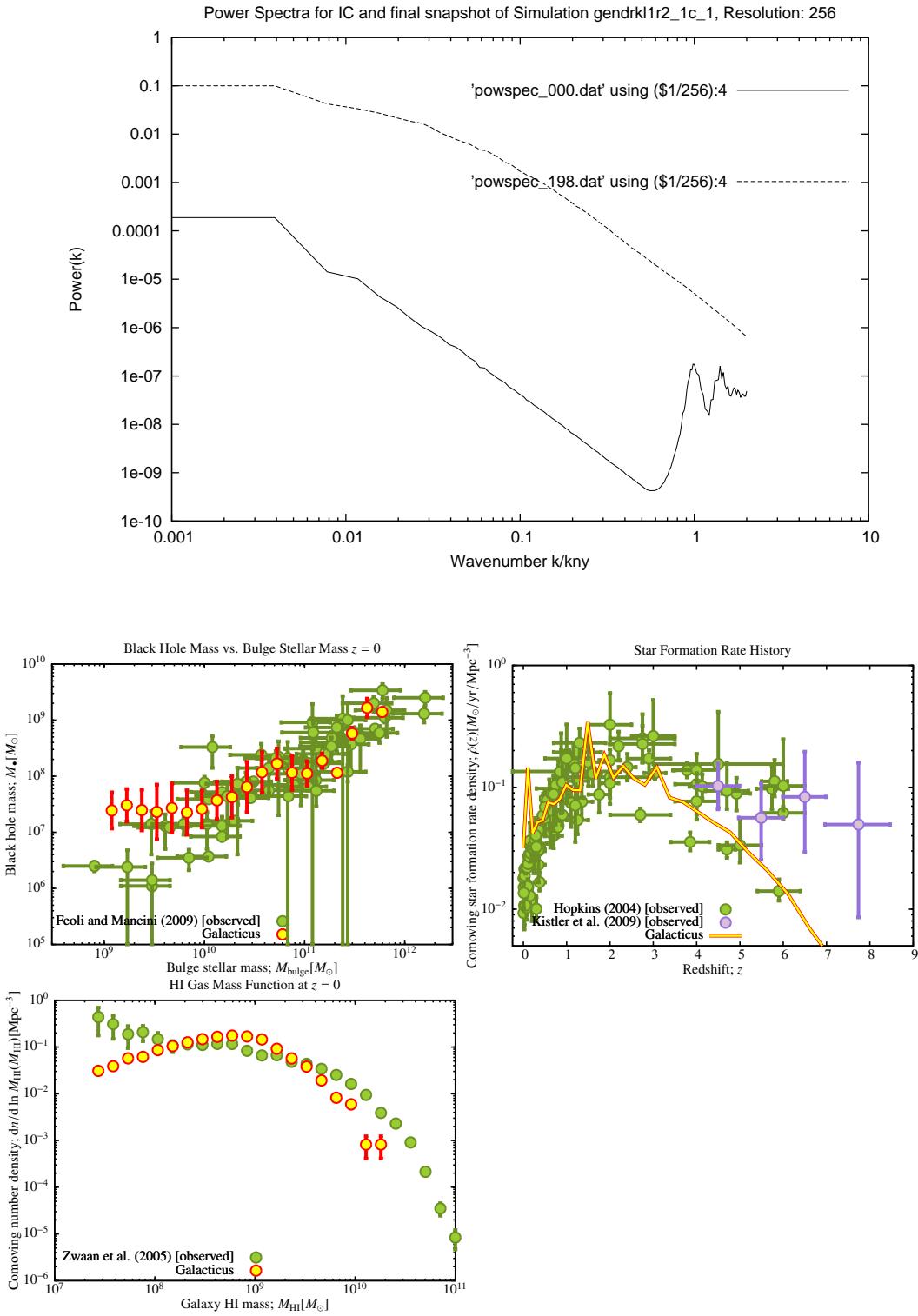
GALACTICUSSED ✓ → gadgetviewer: simulation has "artificial" cross on right upper corner  
→ DUMP IT ?  
→ re-converted with bugfixed converter (v0.3)  
galacticus running on SGE  
is being galacticussed → job seems to run!  
GALACTICUS:

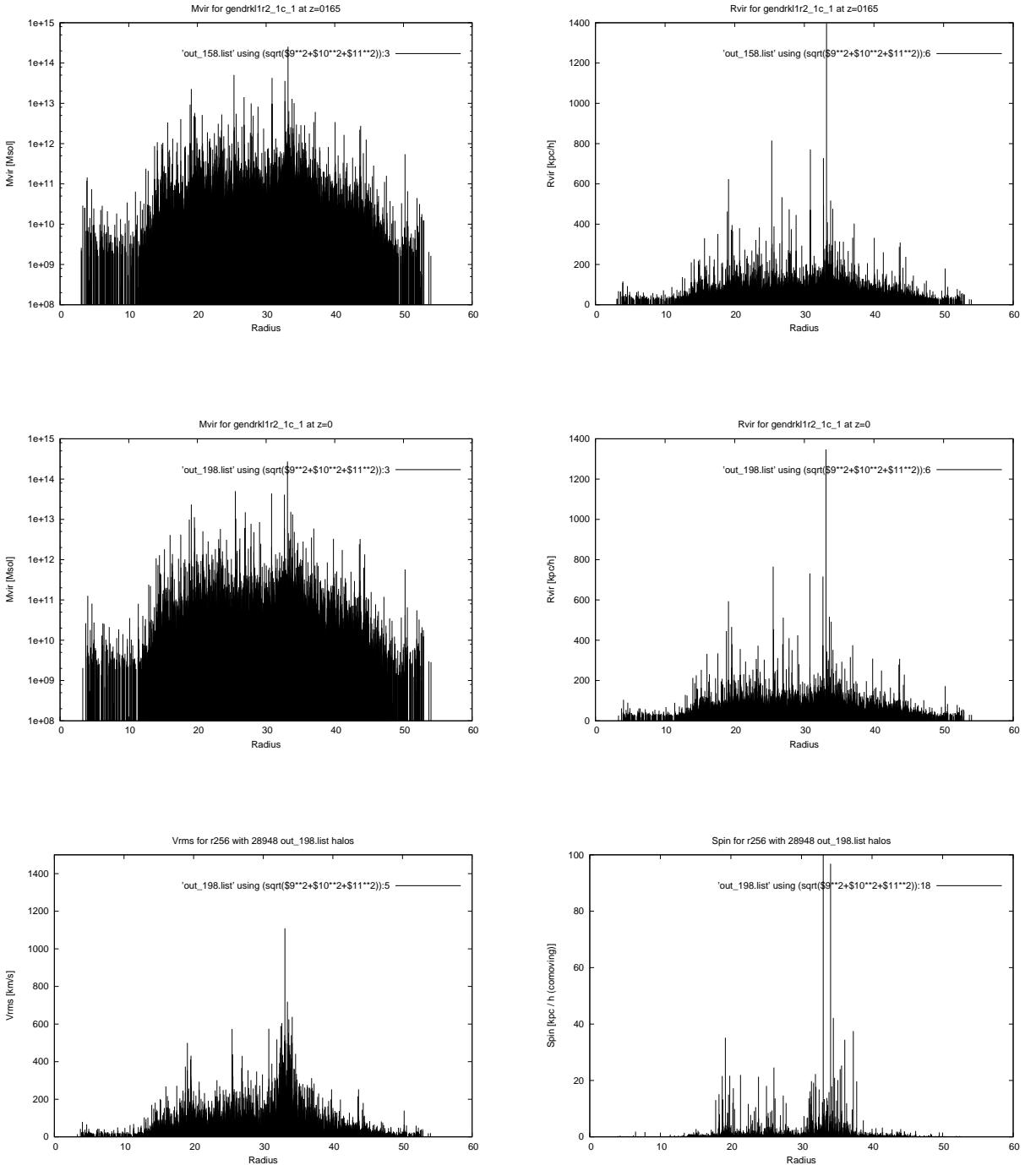
```
Fatal error in Build_Descendent_Pointers():
failed to find descendent node
```

CONSISTENTTREEED ✓  
ROCKSTARRED ✓ (lasted about 9000minutes)

### 2.2.7 gendrkl1r2\_1c\_1







GALACTICUSSED WITH REVISION 709 ✓ CONSISTENTTREED ✓  
 ROCKSTARRED ✓  
 is being rockstarred on `astro-x4600-03`

E-Mail sent to Bertschinger

```
$ diff drkt+3c+s15_1+r2/constraints_drkt+3c+s15_1+r2.f
r128/h100/gendrk11_1c_1/constraints_gendrk11_1c_1.f

$ diff gendrk11r2_1c_1/grafic_inc_gendrk11r2_1c_1.f
r128/h100/gendrk11_1c_1/grafic_inc_gendrk11_1c_1.f
```

```

5c5
< parameter (np1=256,np2=256,np3=256,ncon=1)
---
> parameter (np1=128,np2=128,np3=128,ncon=1)

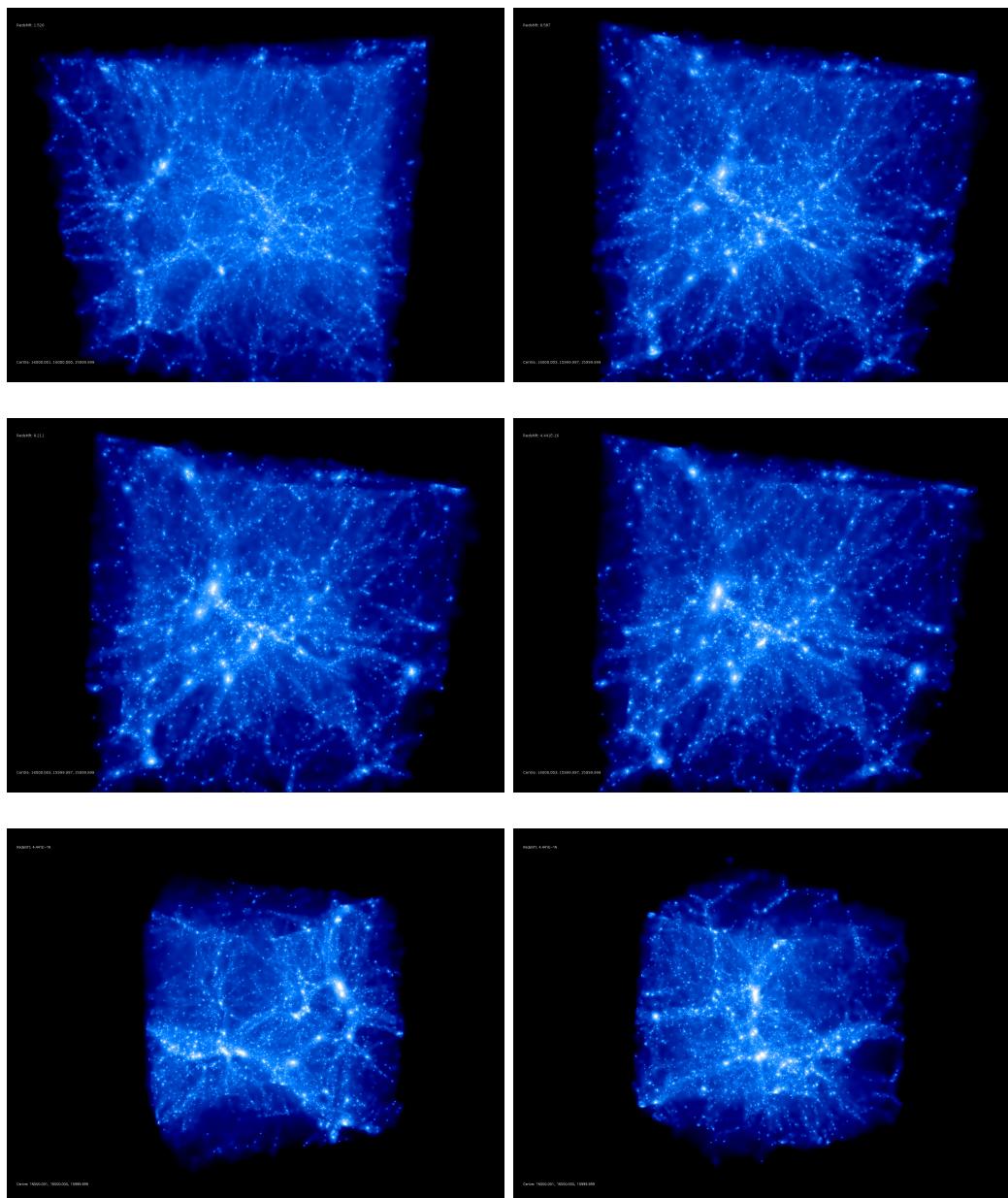
diff gendrk1r2_1c_1/graficIO_gendrk1r2_1c_1.out r128/h100/gendrk1_1c_1/graficIO_gendrk1_1c_1.out
23c23
< Particle lattice size: np1,np2,np3=          256          256          256
---
> Particle lattice size: np1,np2,np3=          128          128          128
25,27c25,27
< chosen: 0.12500000 0.0000000 5.00000007E-02
< npart, L_x, L_y, L_z= 16777216 32.00 32.00 32.00 Mpc
< Particle mass= .1447E+09 solar masses
---
> chosen: 0.25000000 0.0000000 5.00000007E-02
> npart, L_x, L_y, L_z= 2097152 32.00 32.00 32.00 Mpc
> Particle mass= .1158E+10 solar masses
37c37
< ak,akmax= 16.100662 16.000005475554534
---
> ak,akmax= 16.068306 16.000005475554534
40,41c40,41
< Mean sigma_delta, sigma_psi= 4.8100653 4.7177238 Mpc
< Chisq, dof, nu= 16781832. 16777215 0.79710007
---
> Mean sigma_delta, sigma_psi= 4.1531582 4.7162638 Mpc
> Chisq, dof, nu= 2095840.0 2097151 -0.64012647
43c43
< Constraint 1: Sampled, desired= 0.28453870E-02 0.25000000E-01
---
> Constraint 1: Sampled, desired=-0.64672055E-02 0.25000000E-01
46c46
< Sampled, desired= 0.21657717 16.718990
---
> Sampled, desired= 1.1184790 16.713776
49c49
< Constraint 1: Final= 0.25000000E-01
---
> Constraint 1: Final= 0.25000002E-01
52,54c52,54
< sigma_delta, sigma_psi= 4.9692168 7.6522889 Mpc
< Chisq, dof= 16781832. 16777214
< Maximum delta, displacement= 27.548712 17.026833 Mpc
---
> sigma_delta, sigma_psi= 4.2376528 6.6093922 Mpc
> Chisq, dof= 2095838.9 2097150
> Maximum delta, displacement= 22.542503 14.168747 Mpc
56c56
< Scaling density and displacements to a= 2.75129788E-02
---
> Scaling density and displacements to a= 3.36233079E-02
58,59c58,59

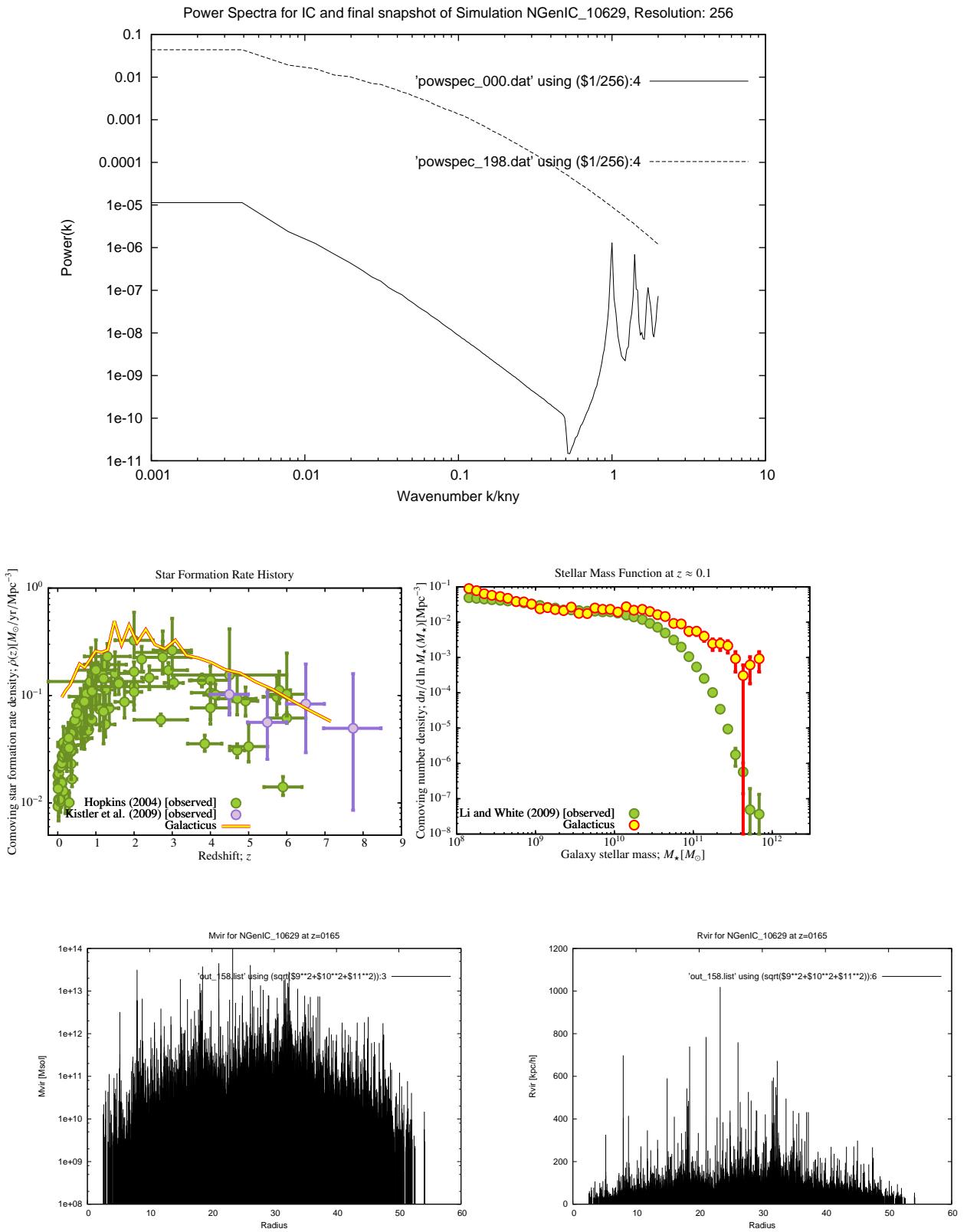
```

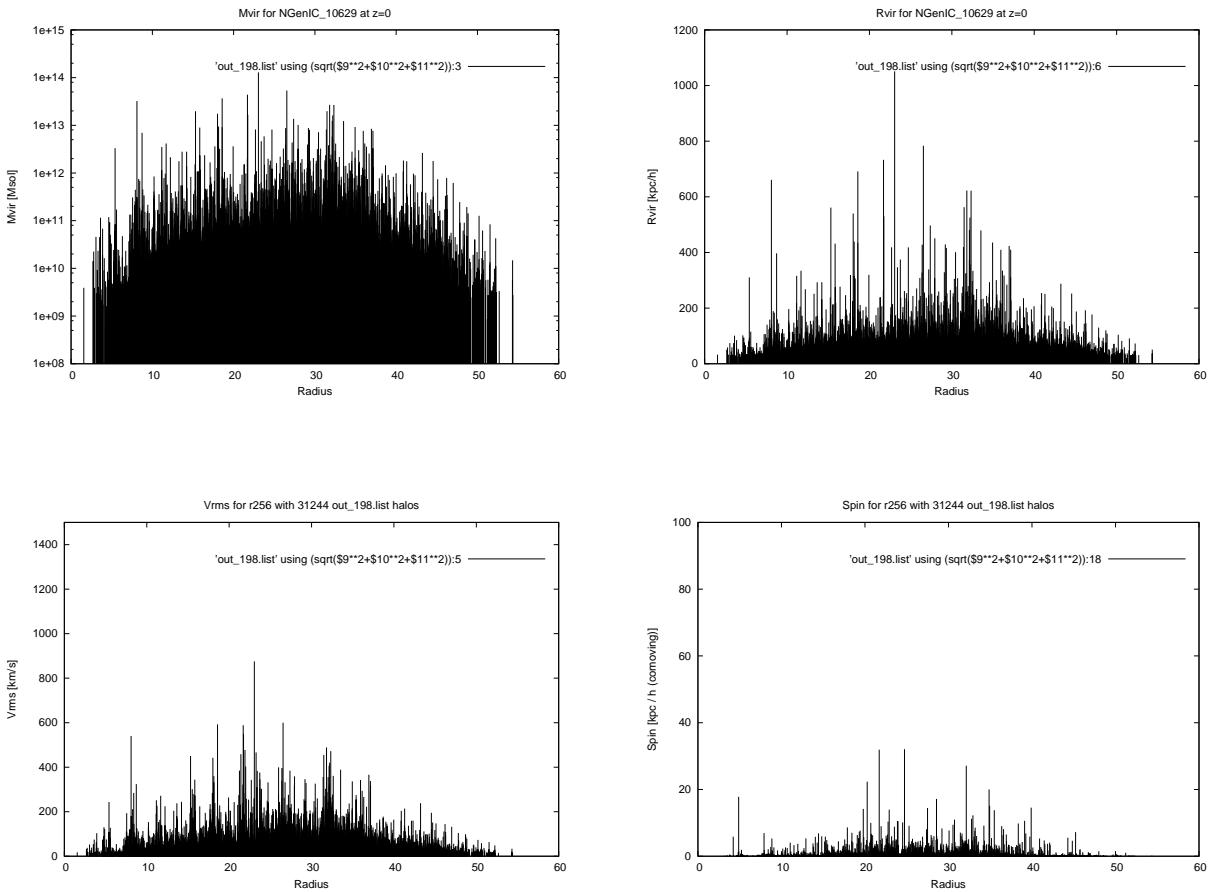
```
< For a=astart: linear sigma, delmax= 0.18037927      0.99999994
< RMS, max. 3-D displacement= 0.27777302      0.61806273      Mpc
---
> For a=astart: linear sigma, delmax= 0.18798503      1.0000000
> RMS, max. 3-D displacement= 0.29319692      0.62853473      Mpc
```

This run is a test if r256 and r128 (`gendrkl_1c_1`) are comparable → see pictures. Sims are not only different in resolution!

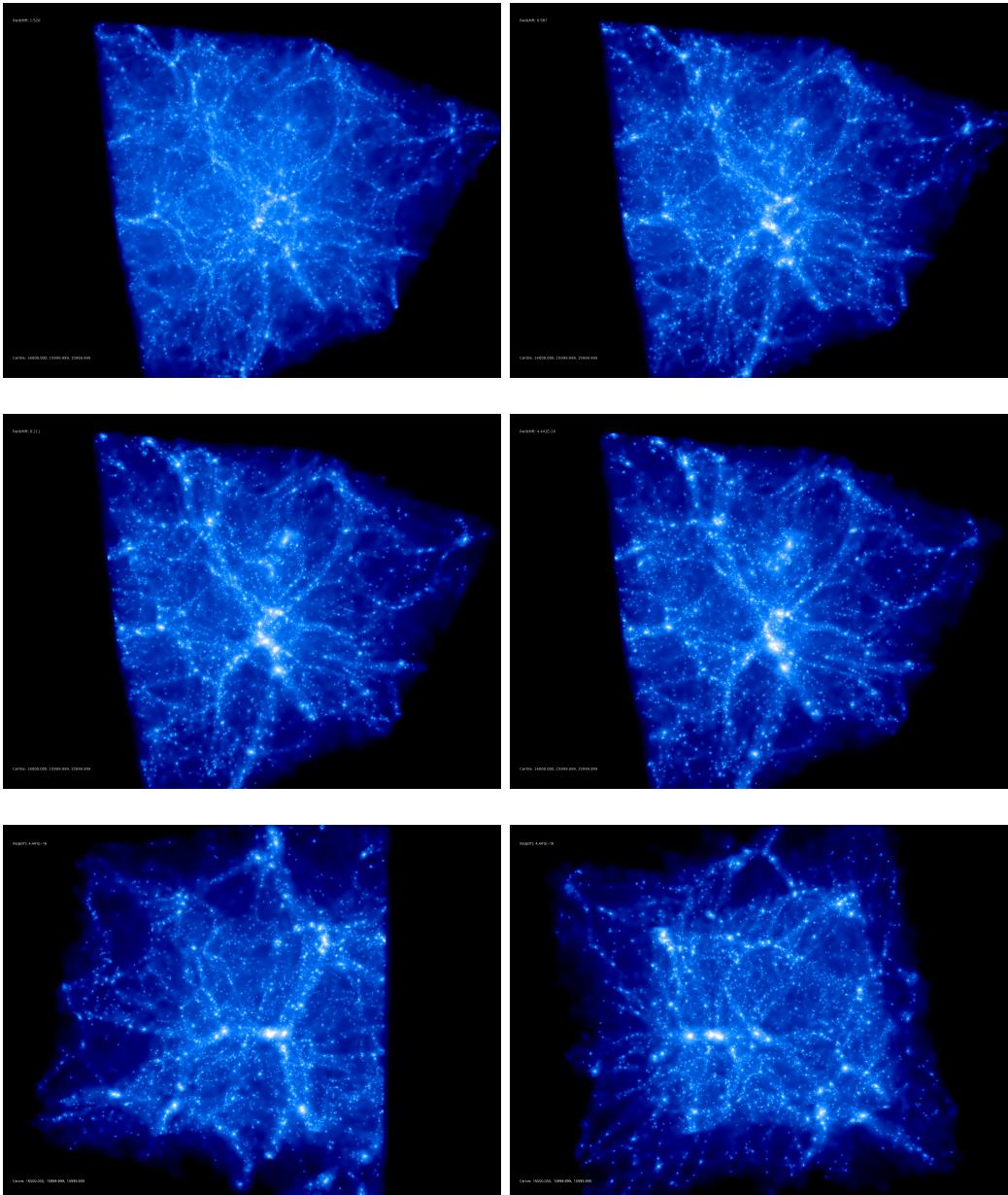
### 2.2.8 NGenIC\_10629

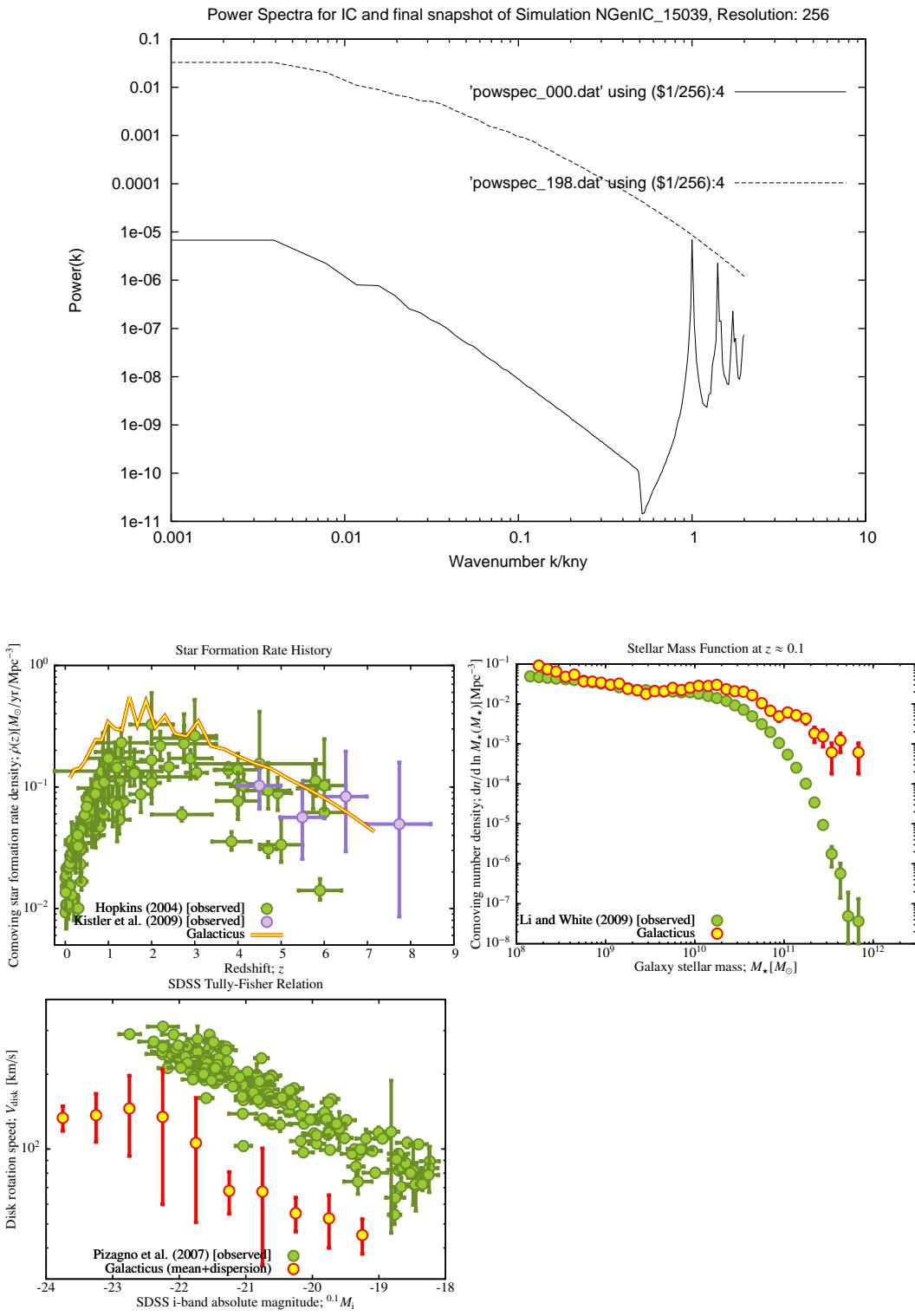


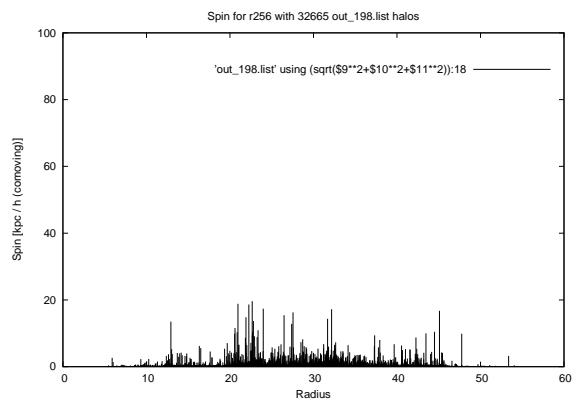
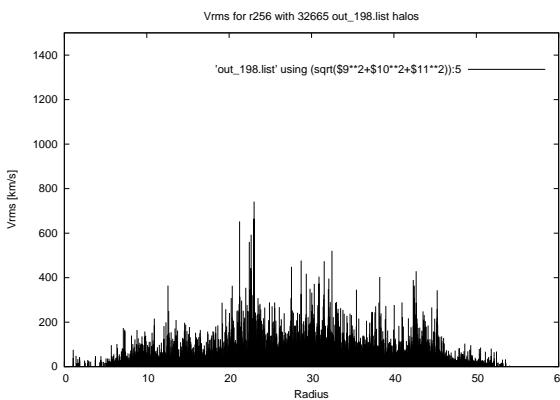
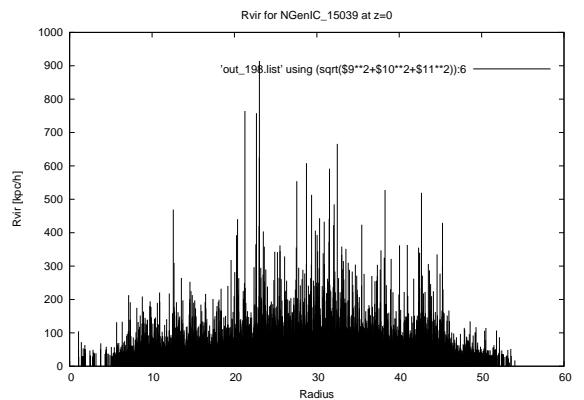
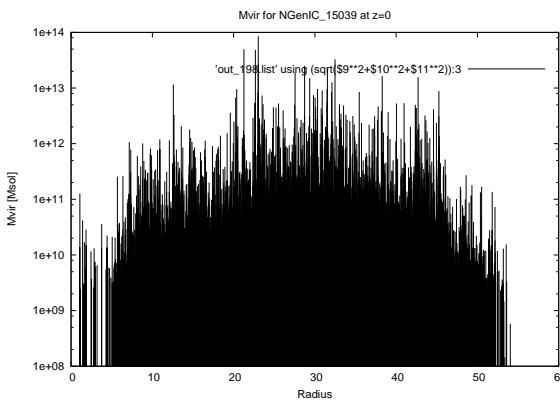
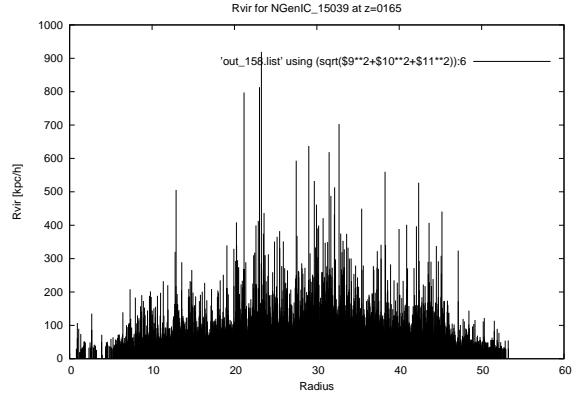
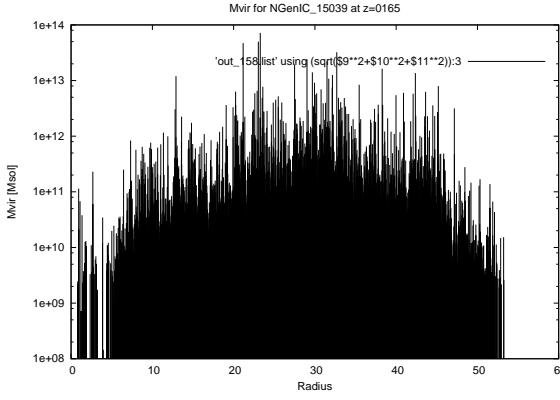




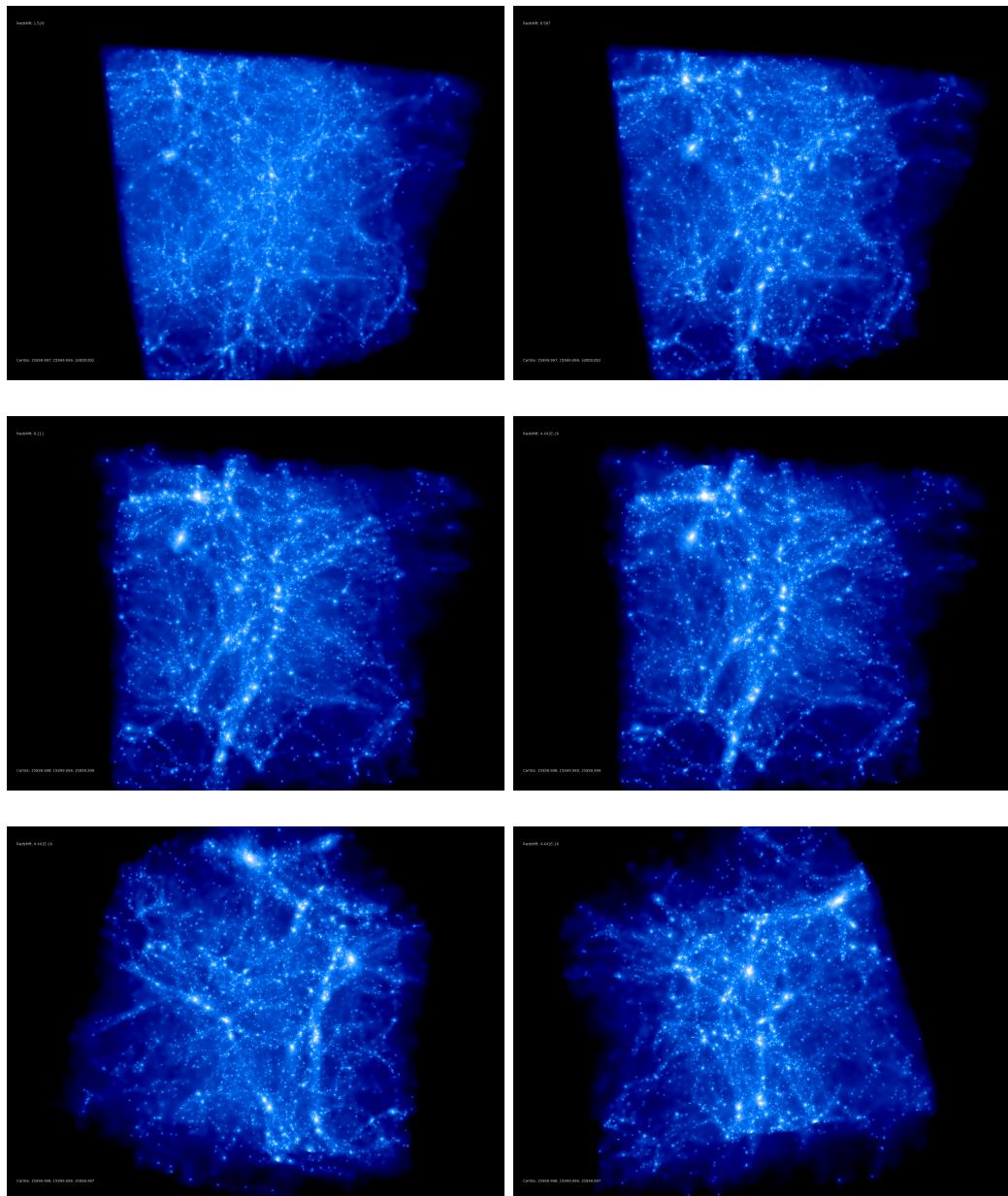
### 2.2.9 NGenIC\_15039

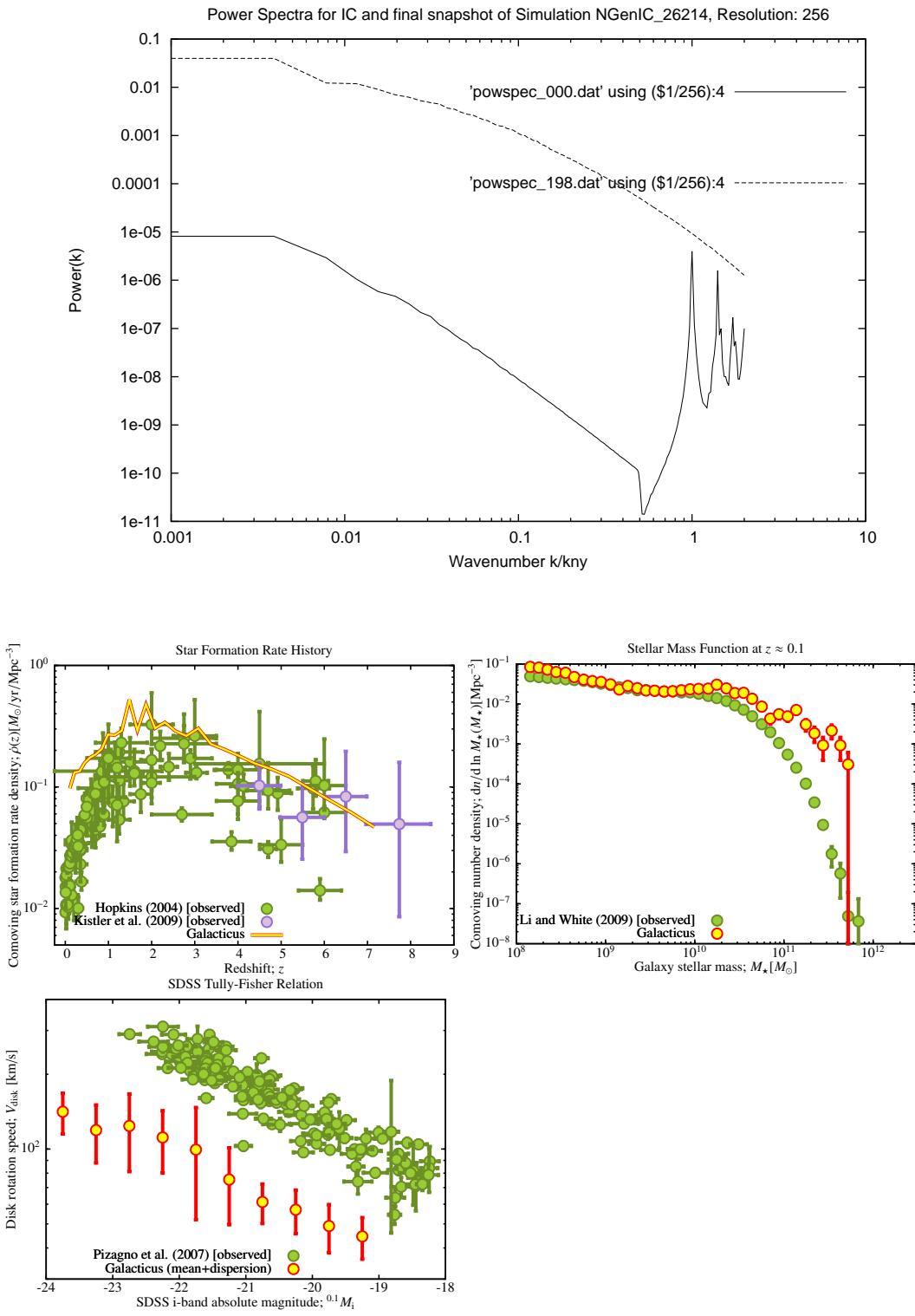


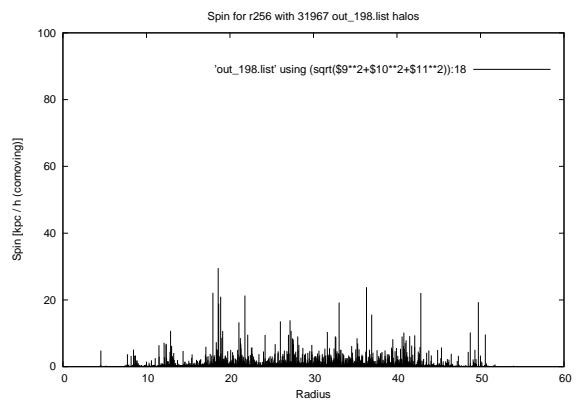
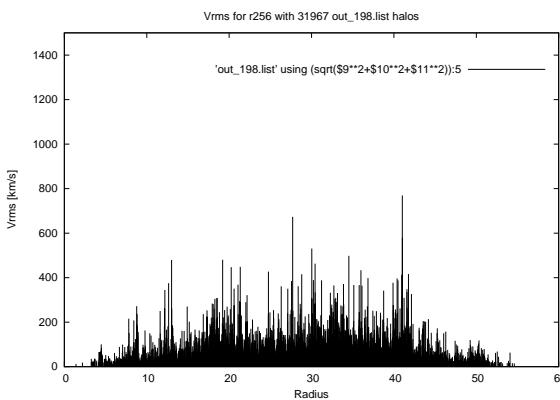
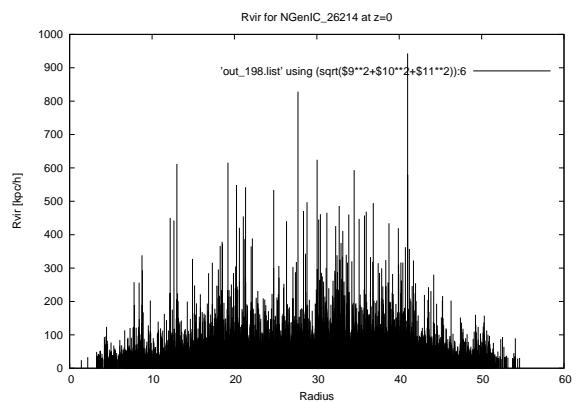
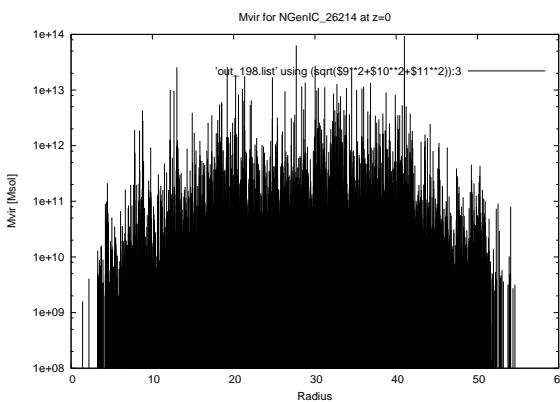
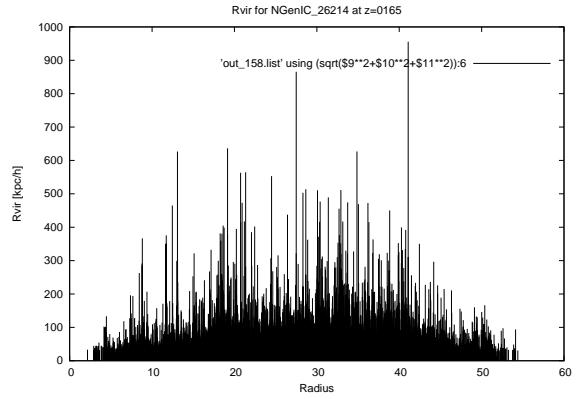
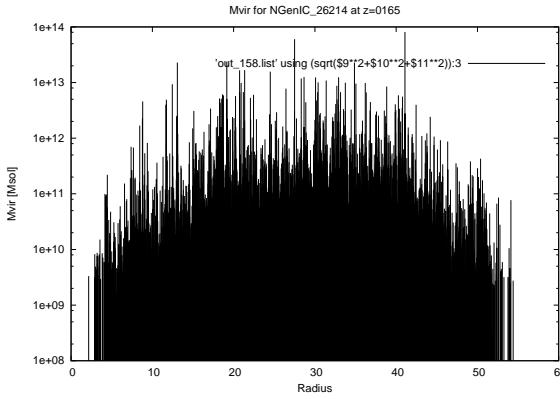




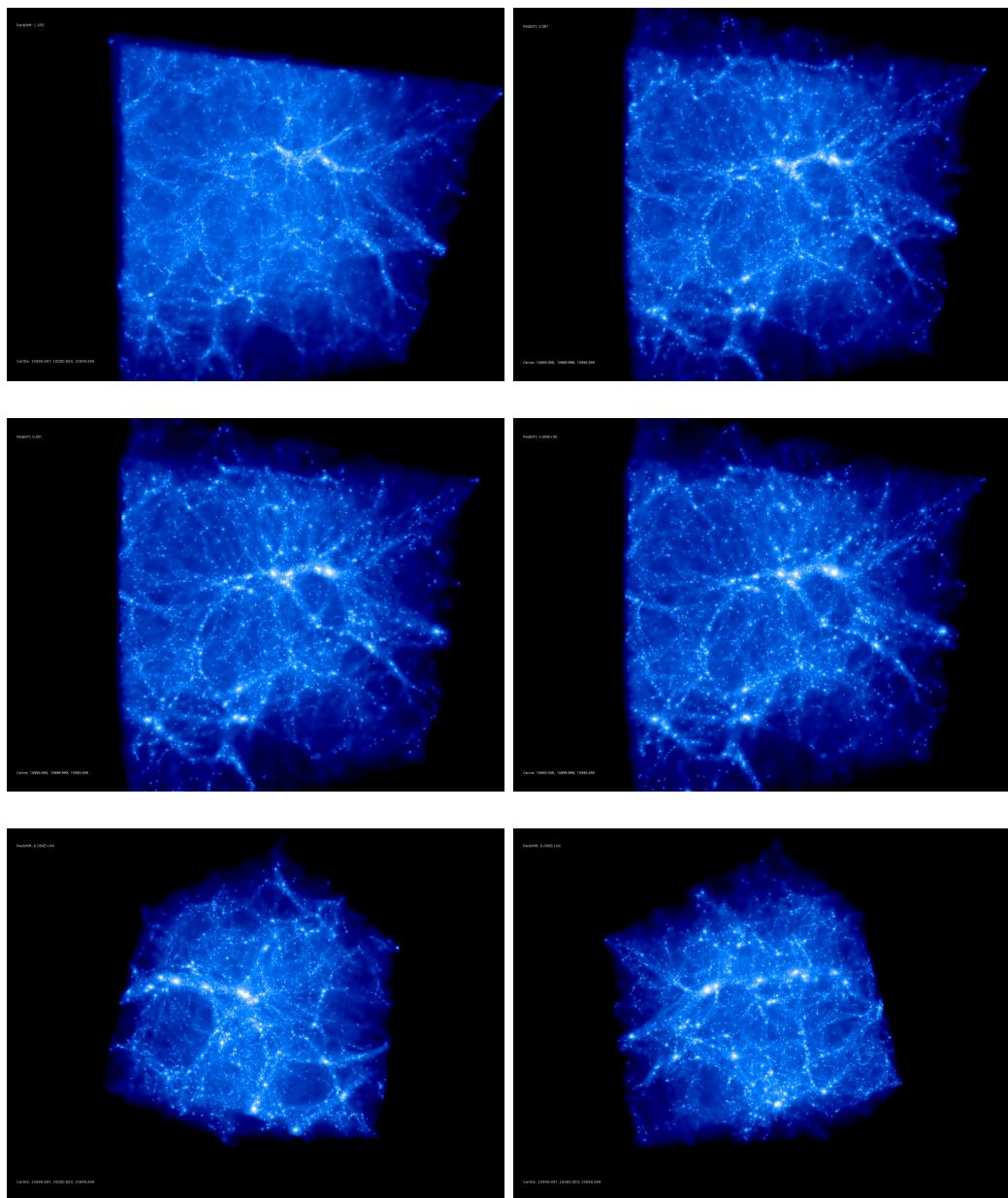
### 2.2.10 NGenIC\_26214

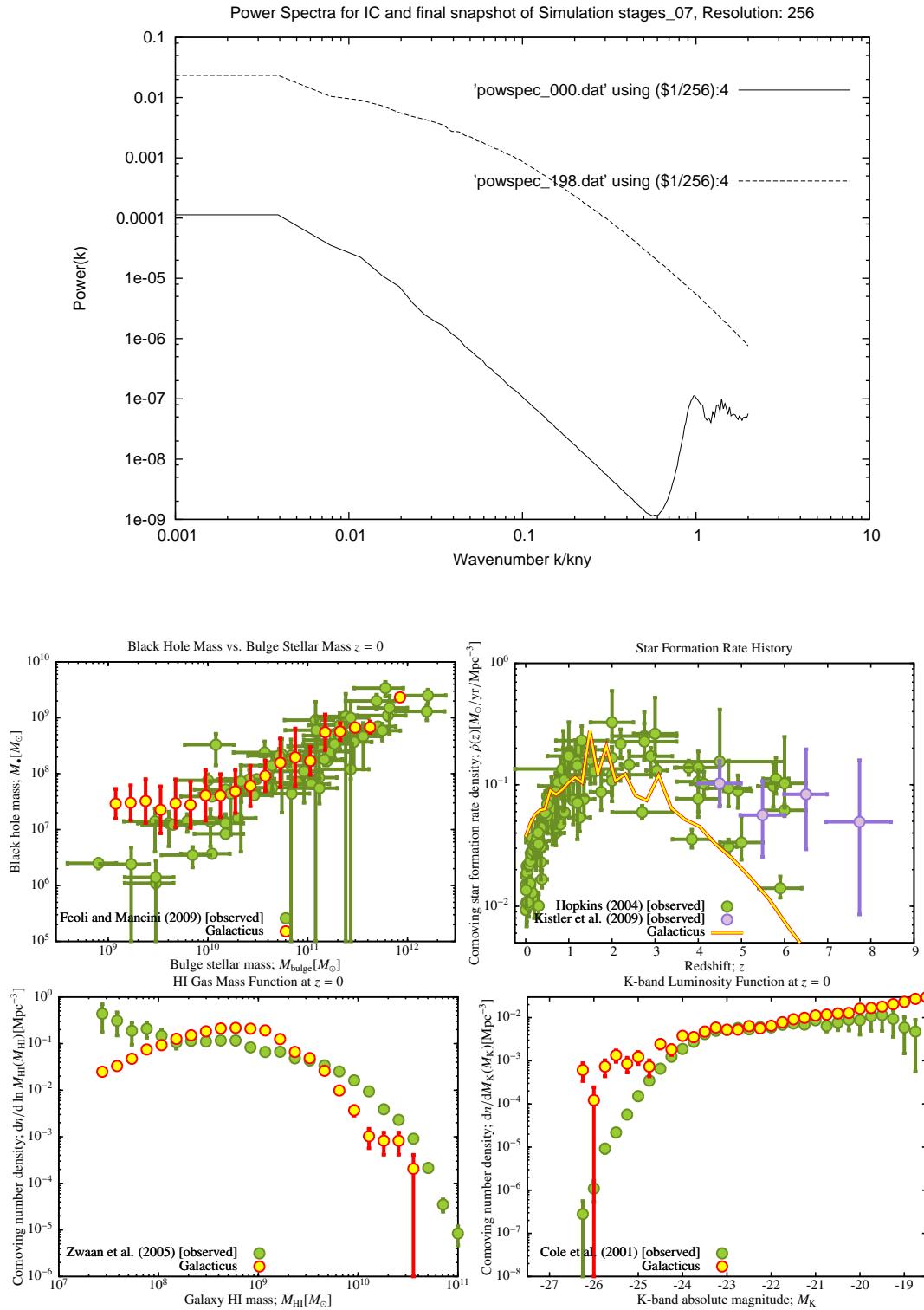


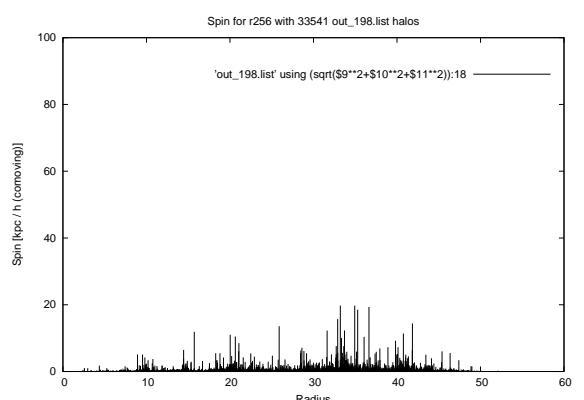
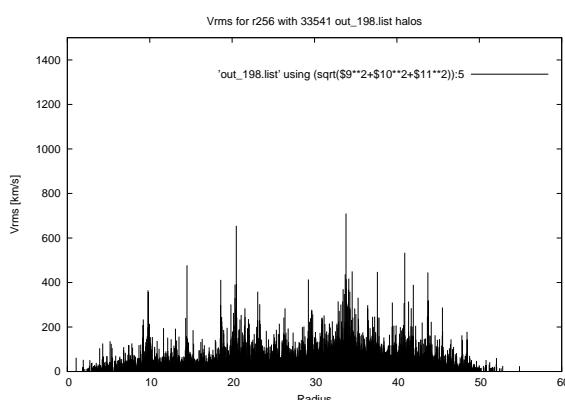
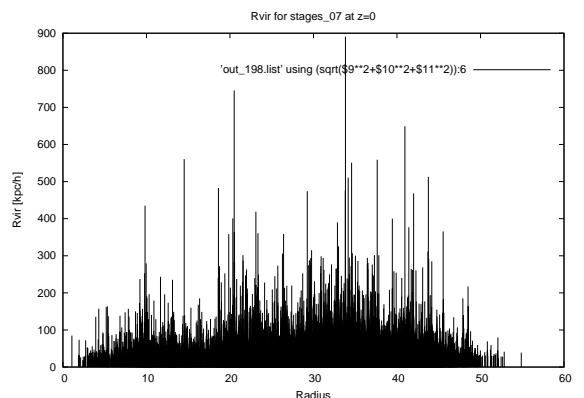
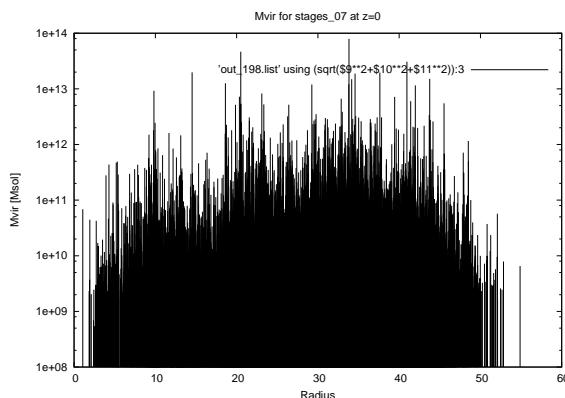
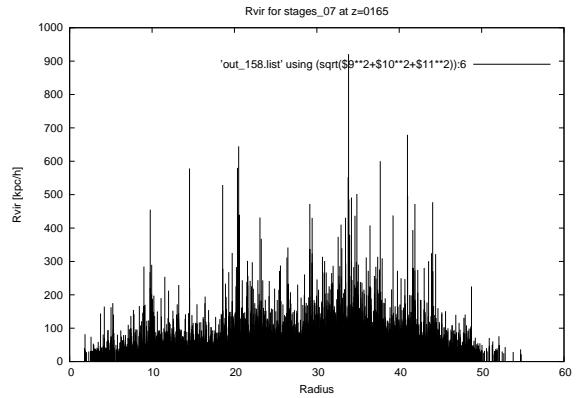
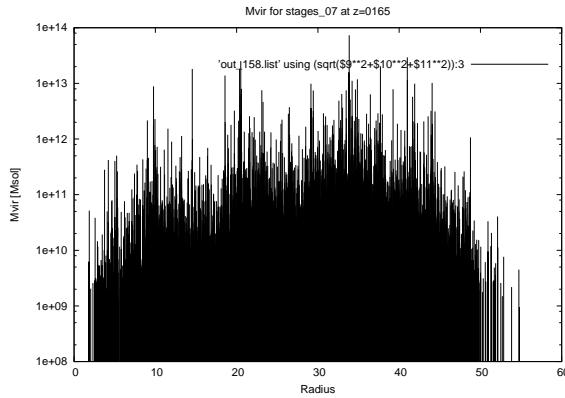
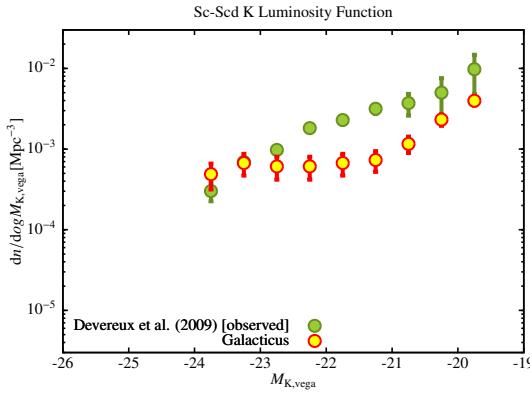




### 2.2.11 stages\_07

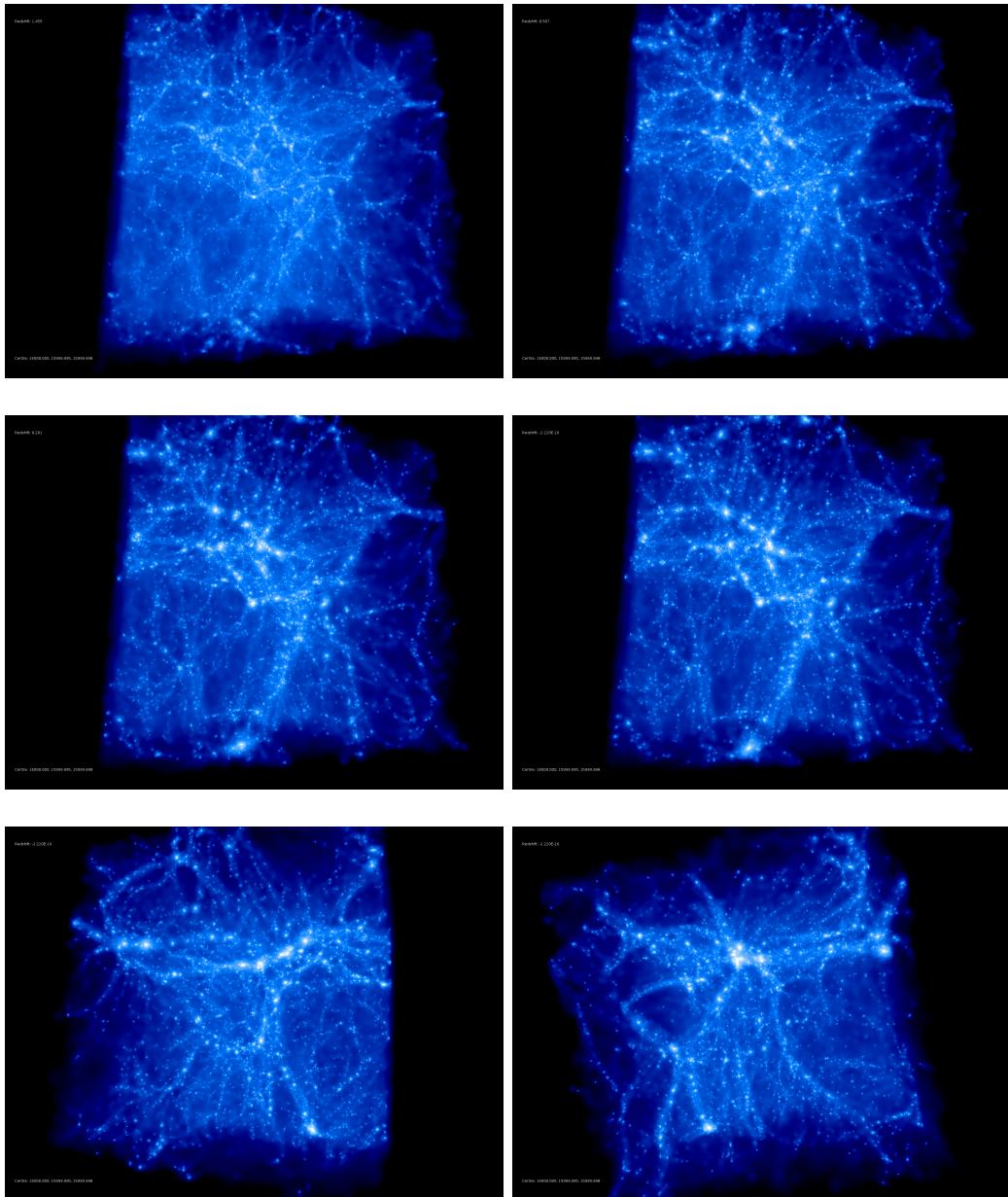


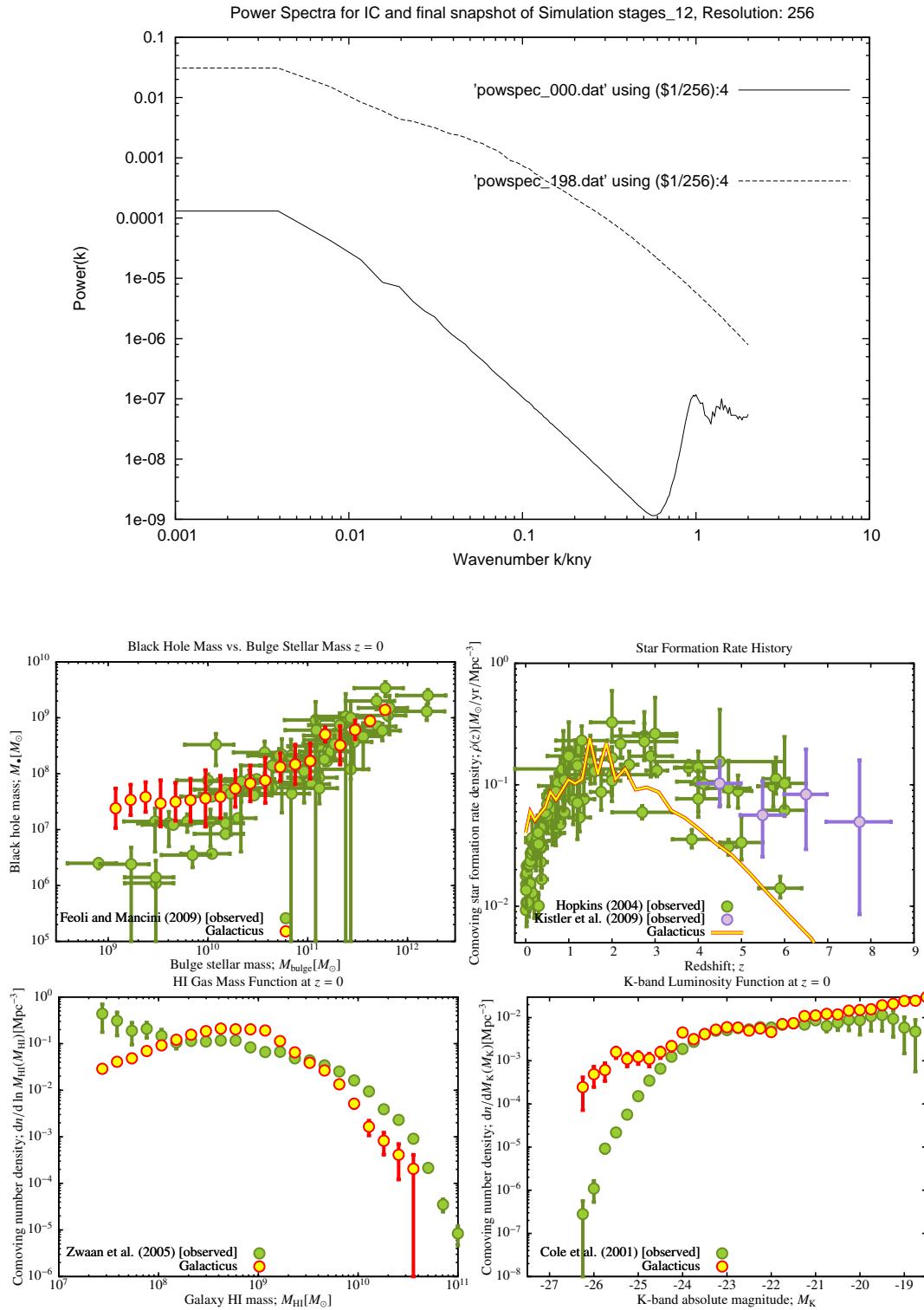


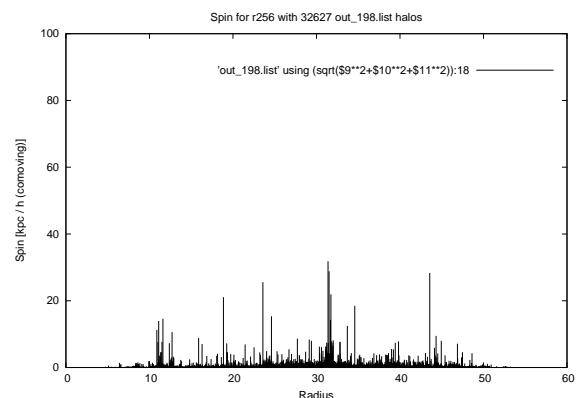
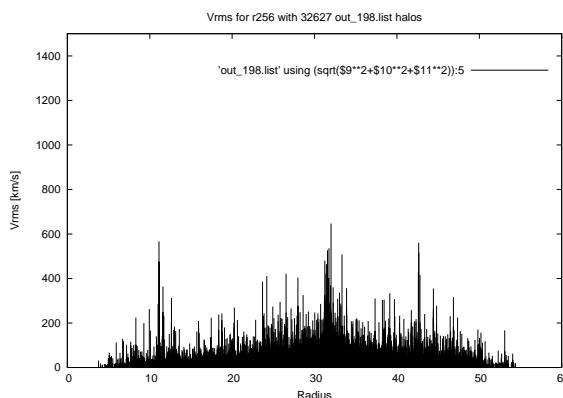
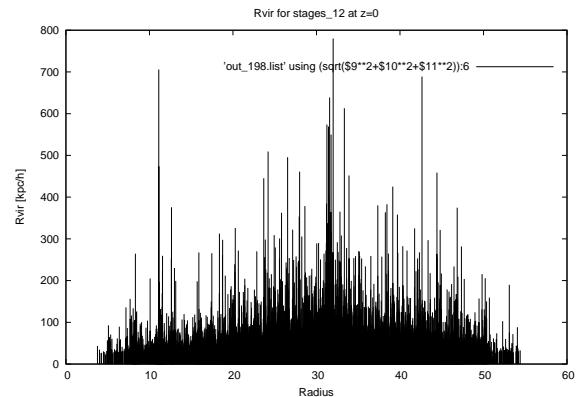
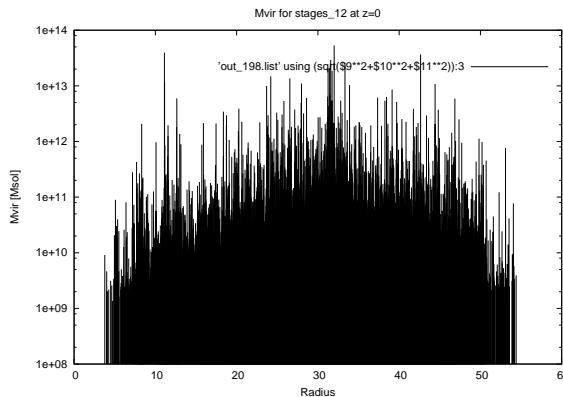
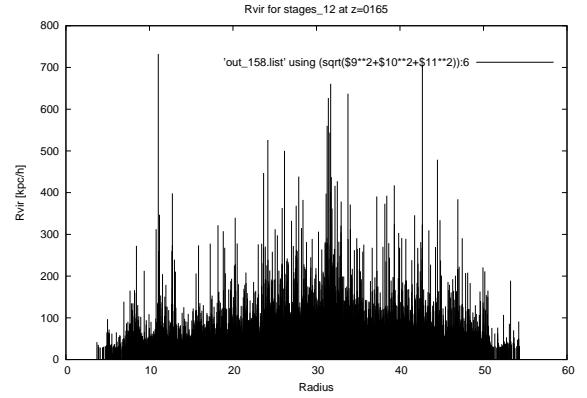
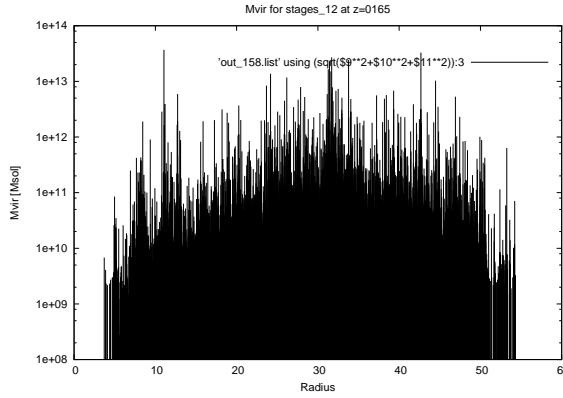
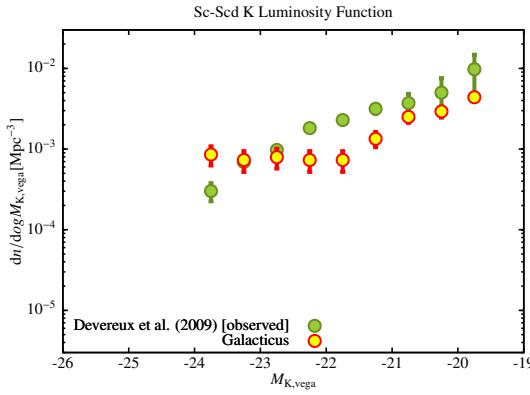


GALACTICUSSED ✓ CONSISTENTTREEED ✓  
ROCKSTARRED ✓

### 2.2.12 stages\_12







after Markus converter update is being galacticussed again  
galacticus strange error:

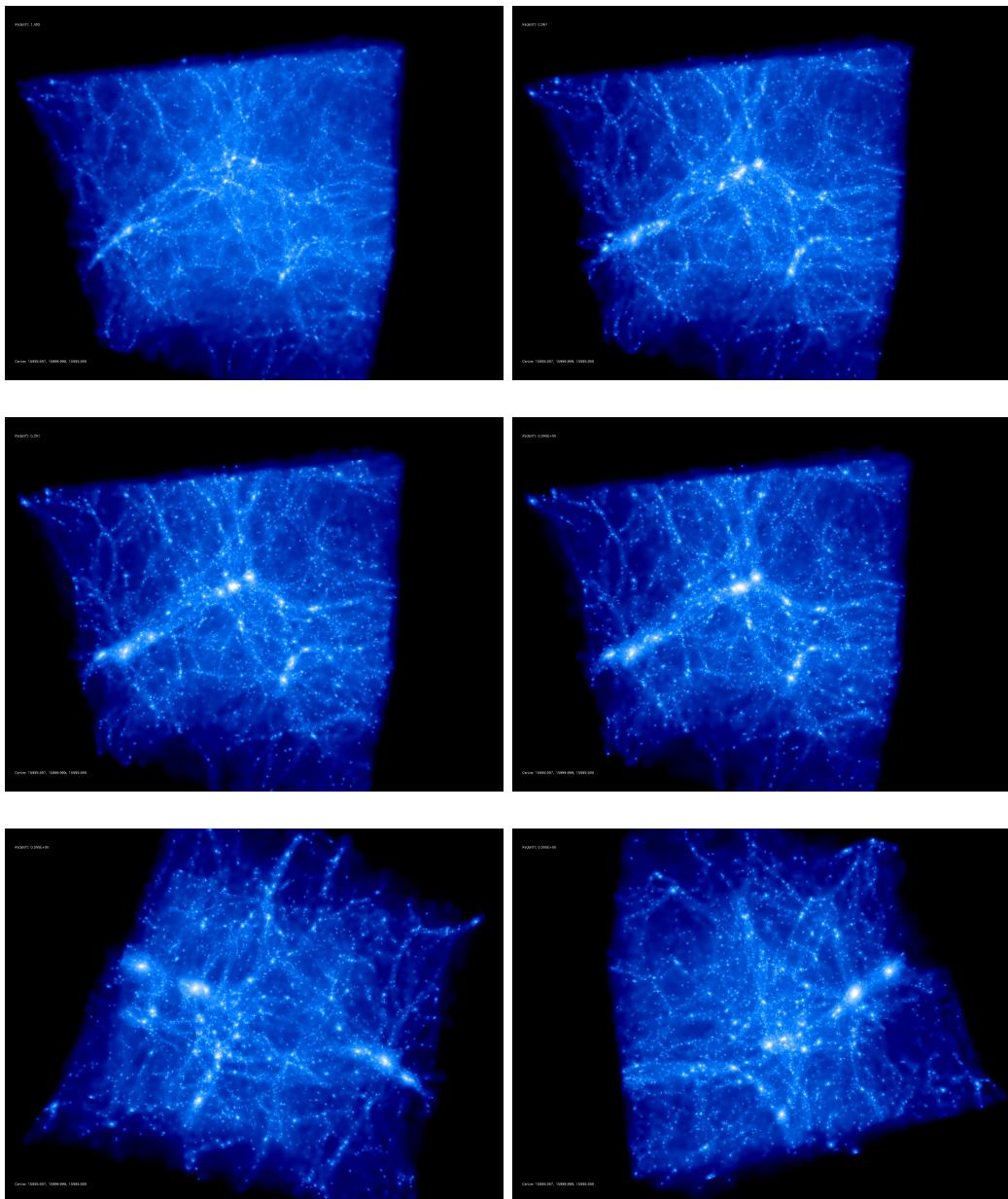
```
Fatal error in Cosmology_Age_Matter_Lambda():
expansion factor is invalid
```

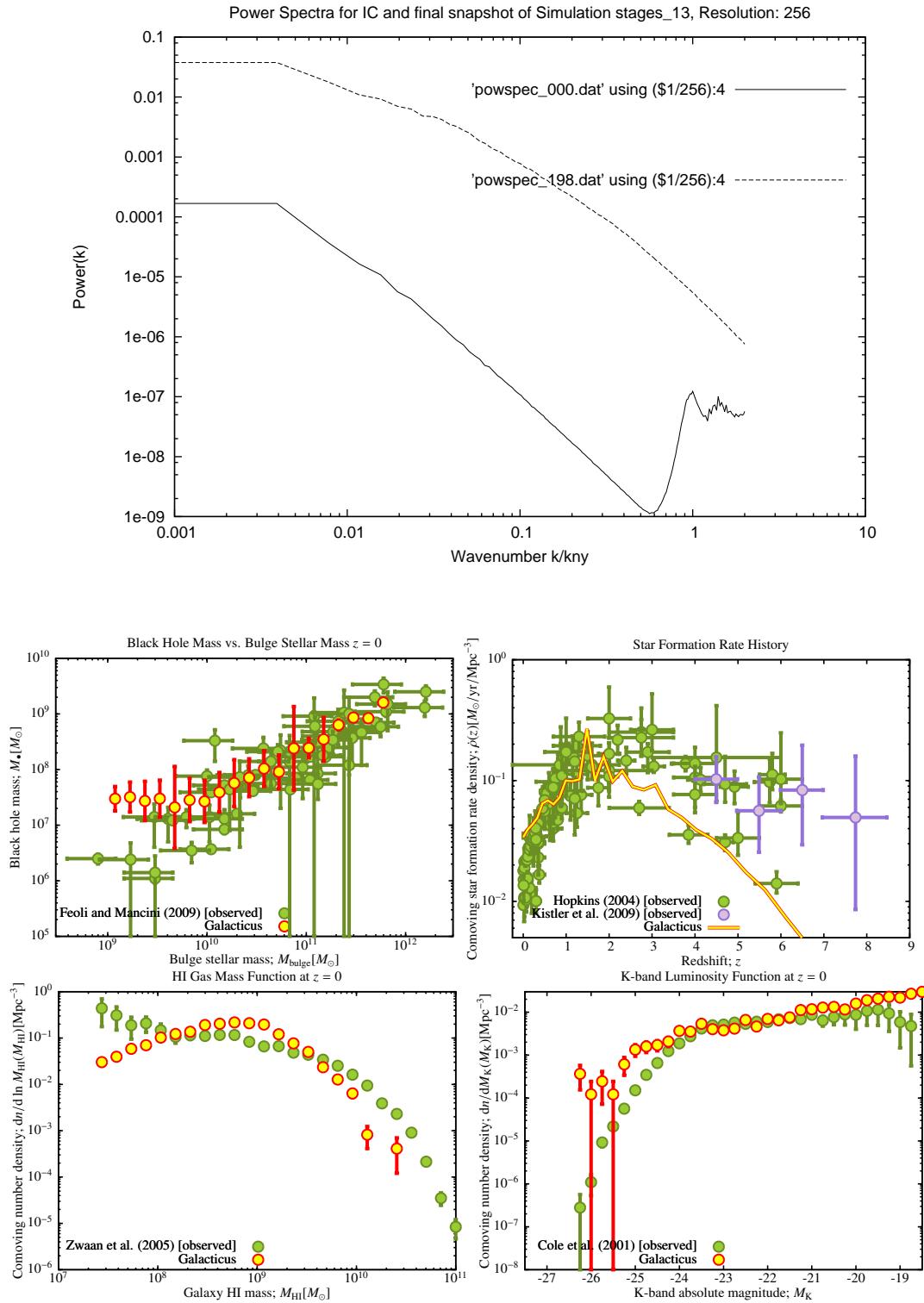
is being galacticussed

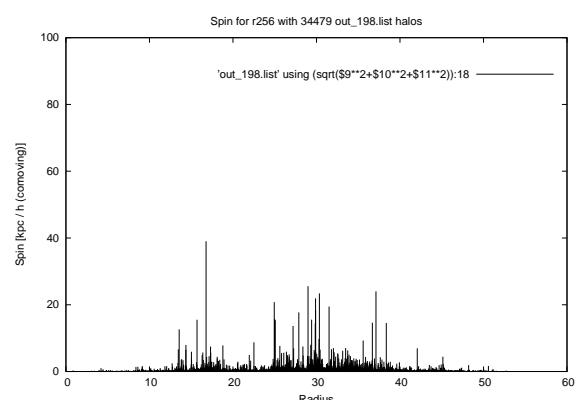
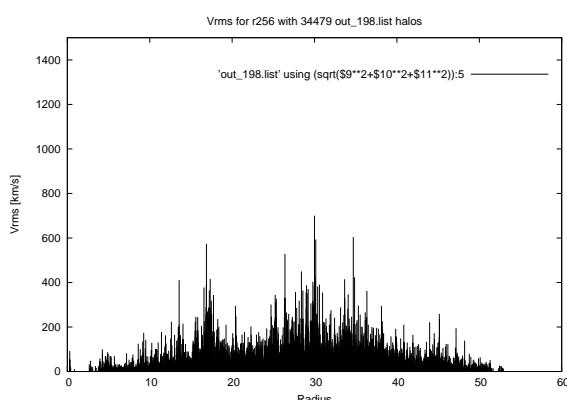
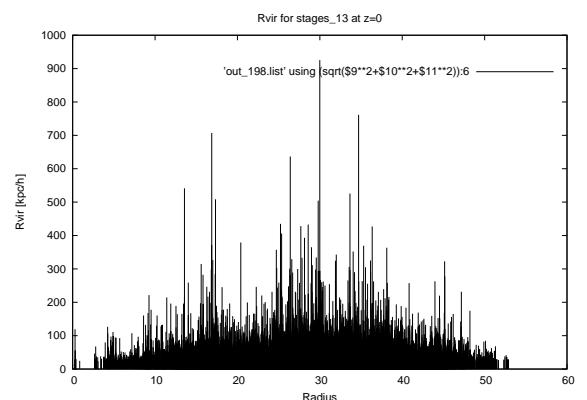
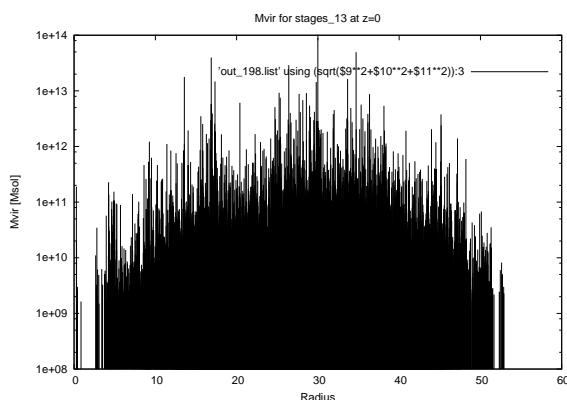
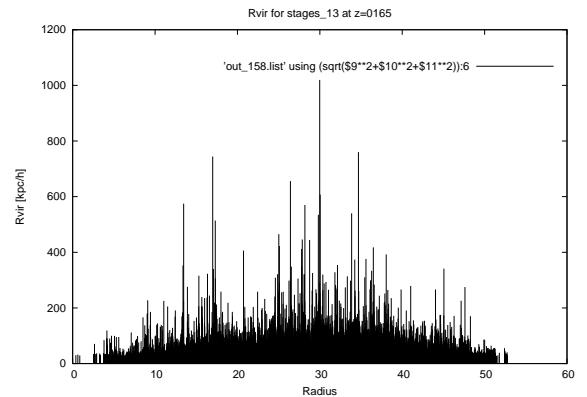
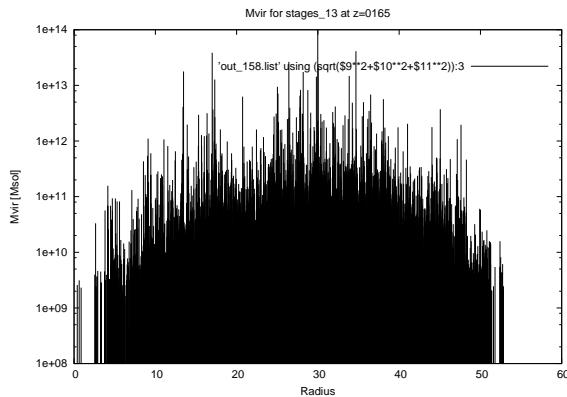
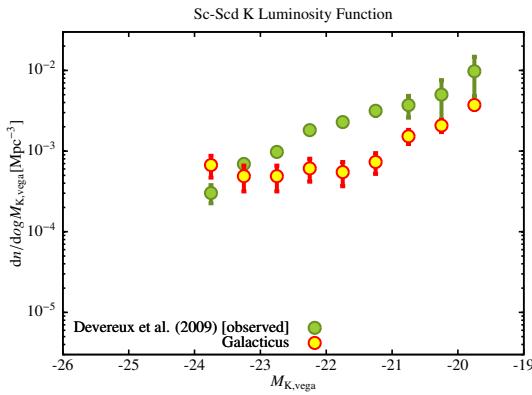
CONSISTENTTREED ✓

ROCKSTARRED ✓

### 2.2.13 stages\_13







GALACTICUSSED ✓

after Markus converter update is being galacticussed again  
galacticus strange error:

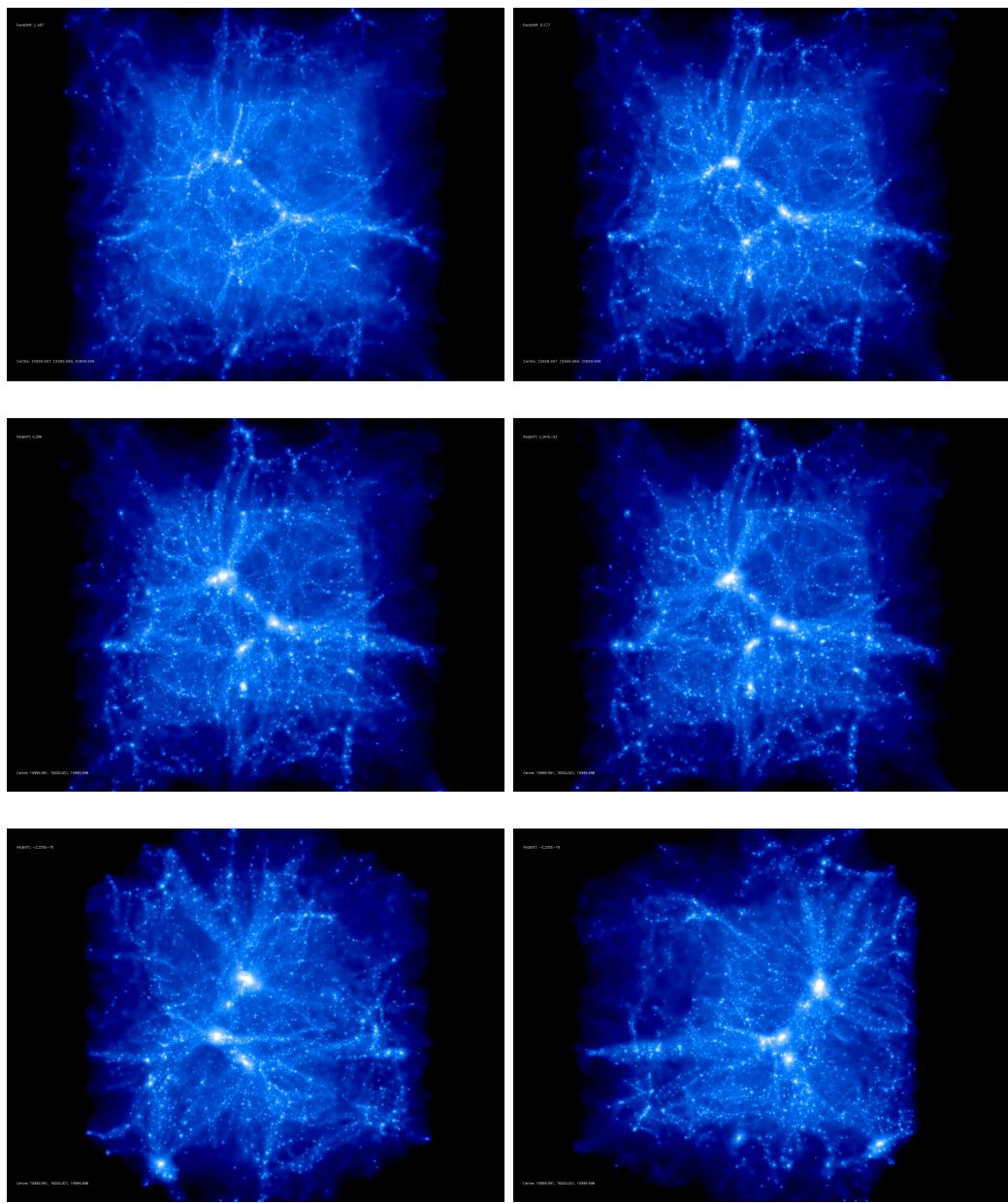
Fatal error in Cosmology\_Age\_Matter\_Lambda():  
expansion factor is invalid

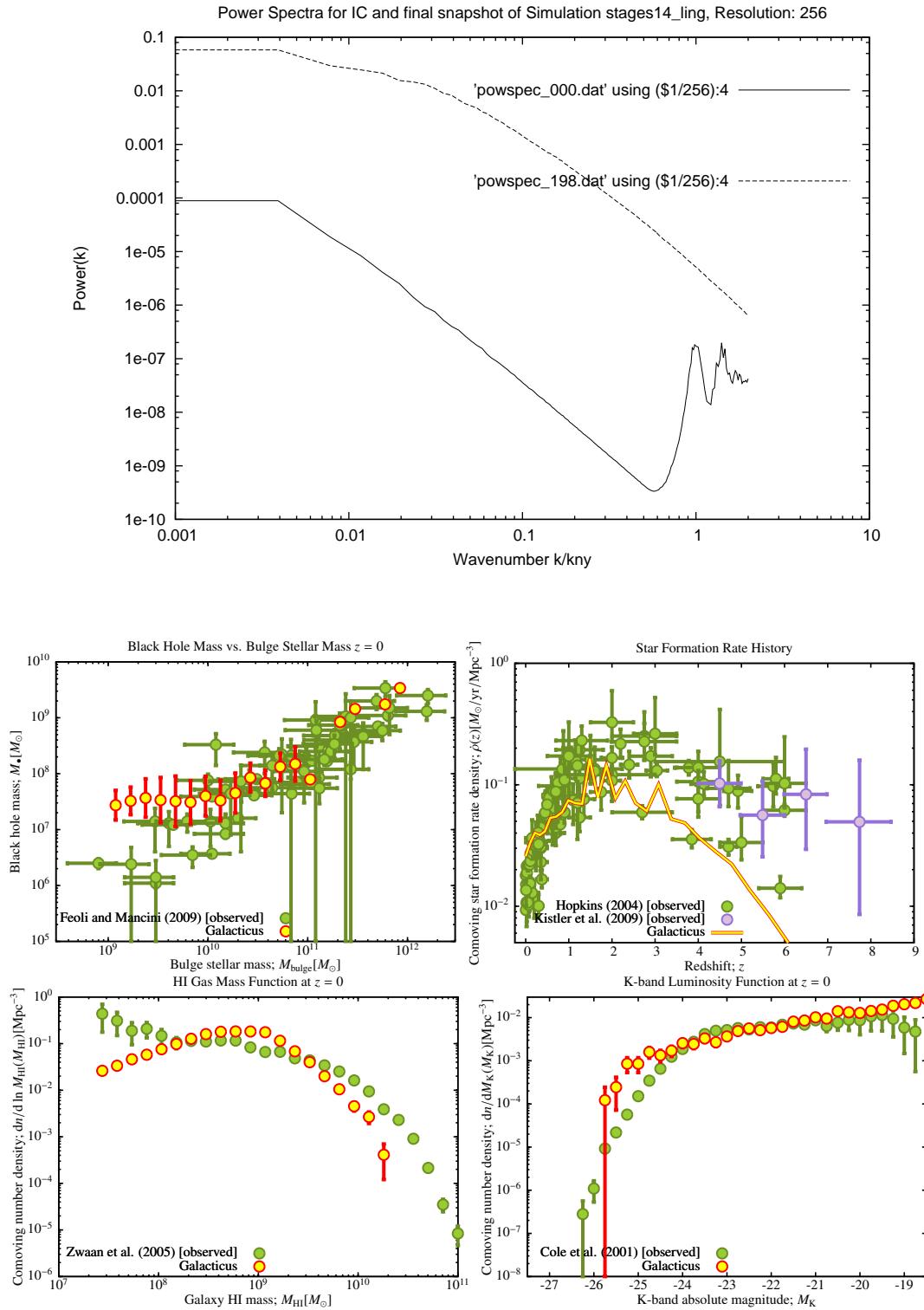
is being galacticussed

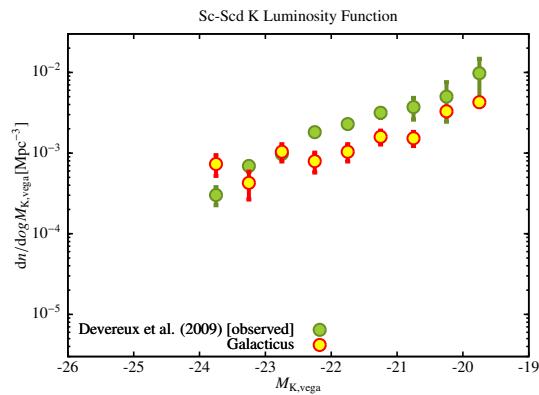
CONSISTENTTREED ✓

ROCKSTARRED ✓

### 2.2.14 stages14\_ling

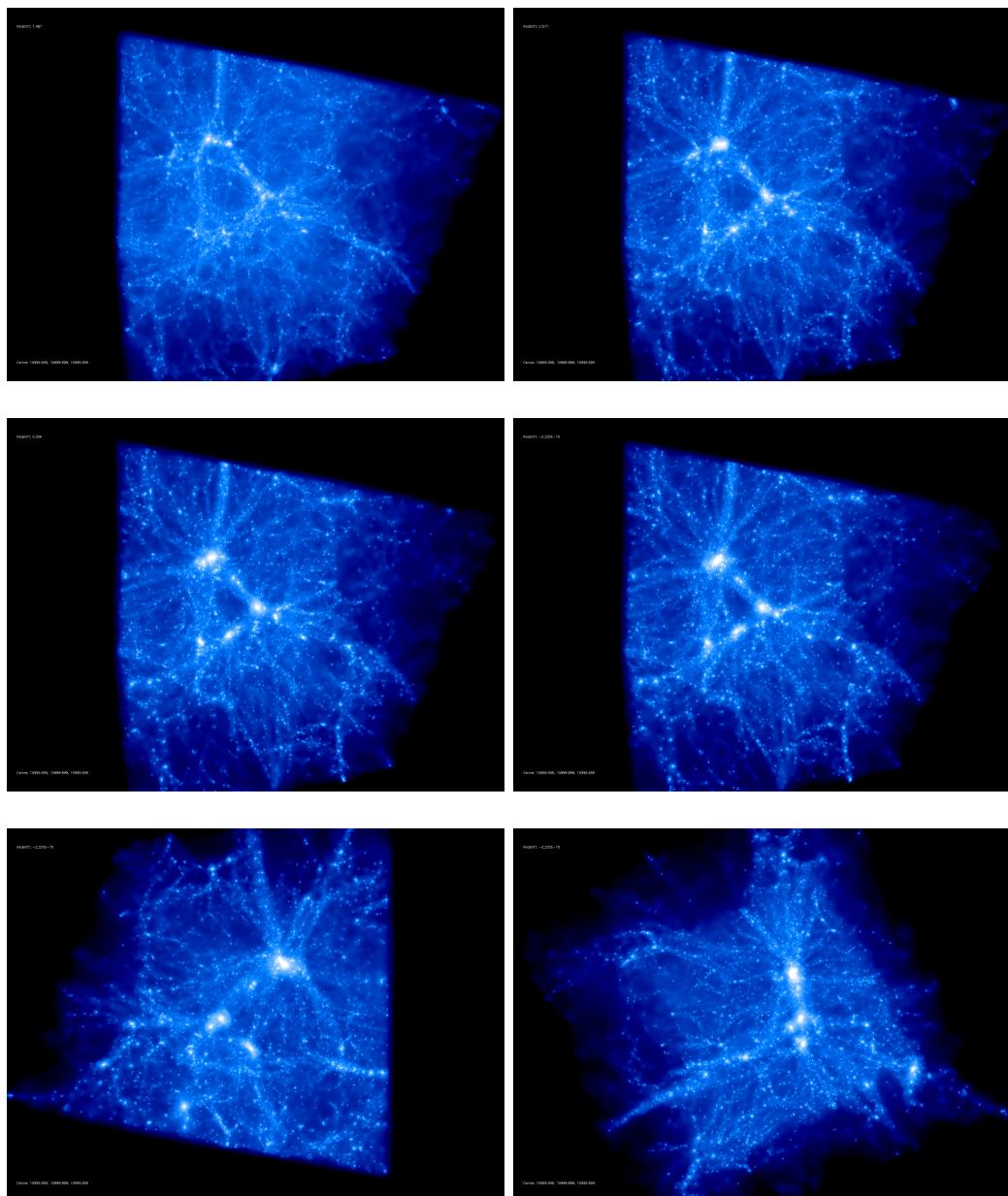


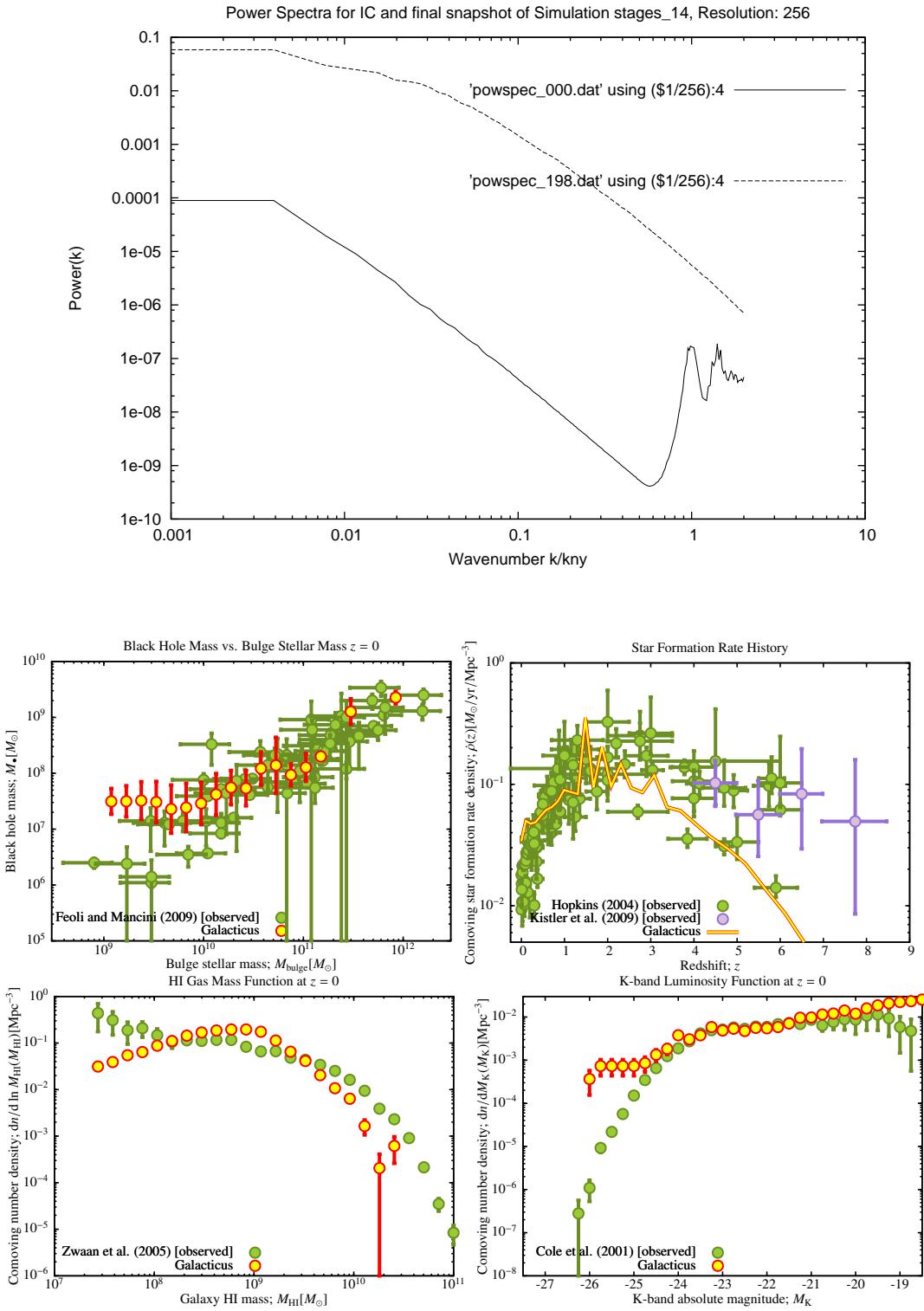


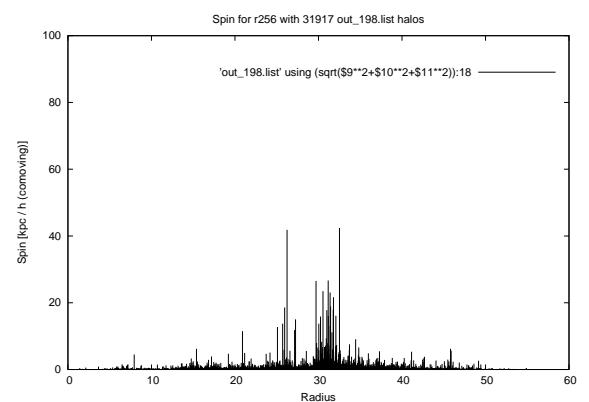
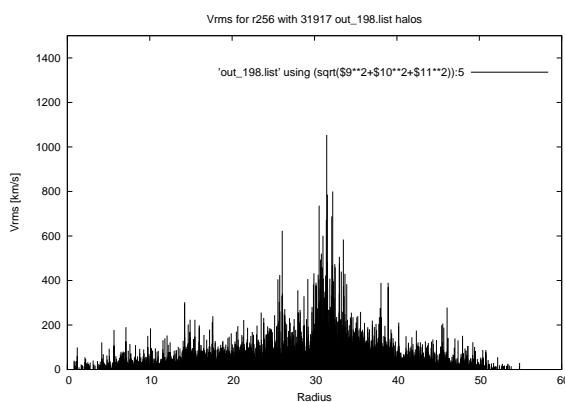
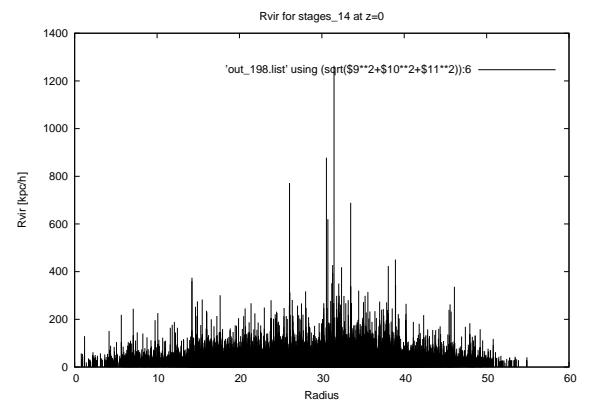
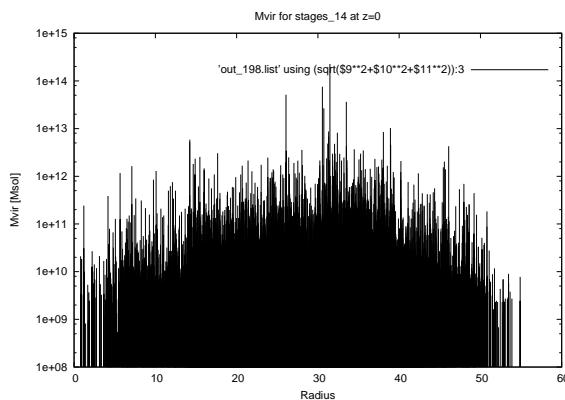
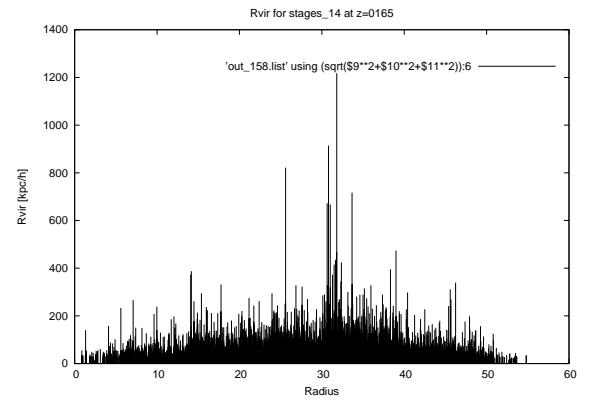
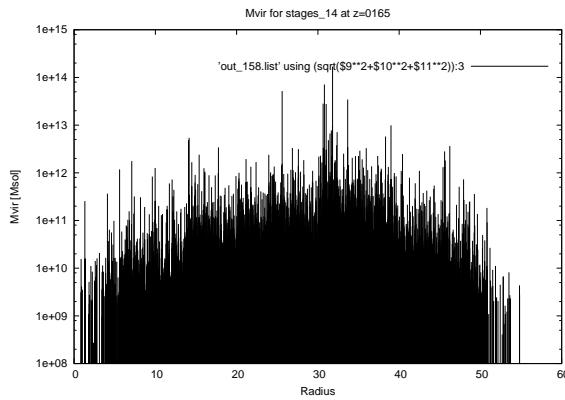
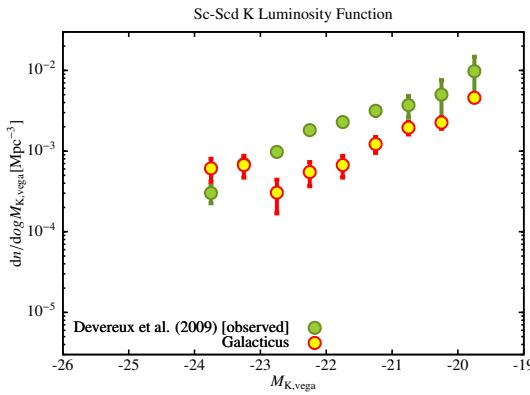


GALACTICUSSED ✓  
CONSISTENTTREED ✓  
ROCKSTARRED ✓

### 2.2.15 stages\_14

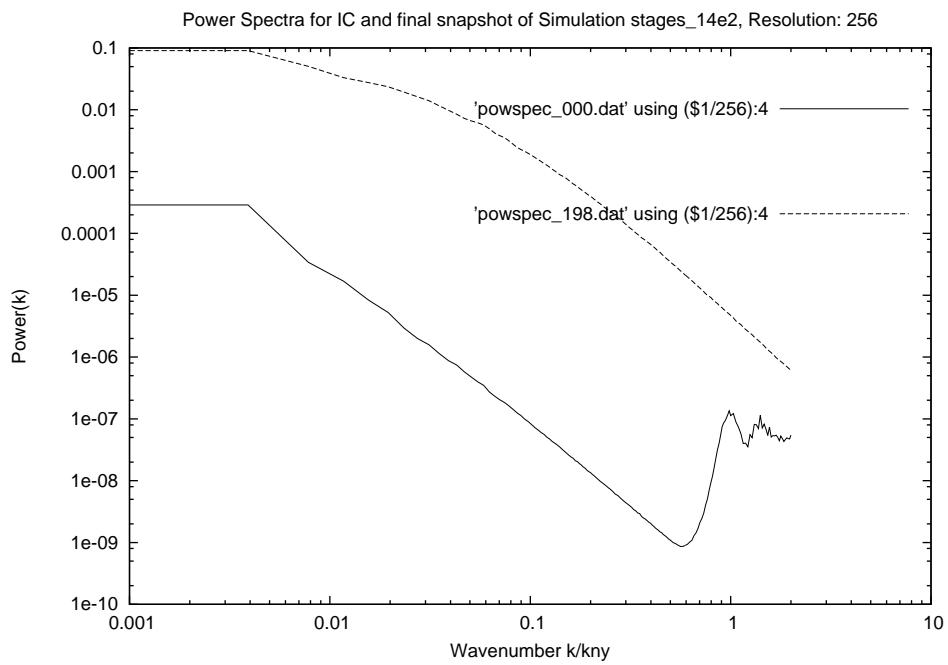




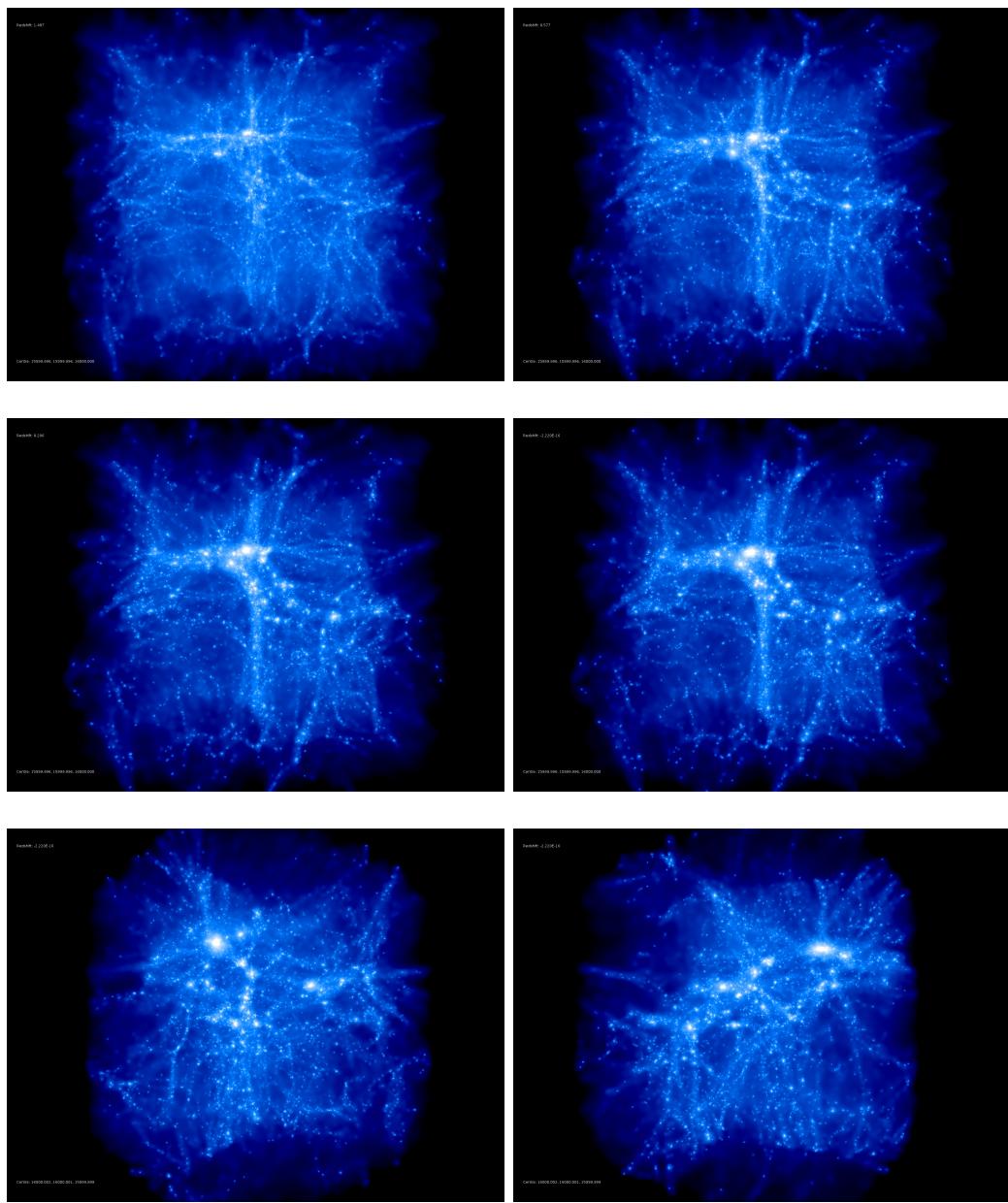


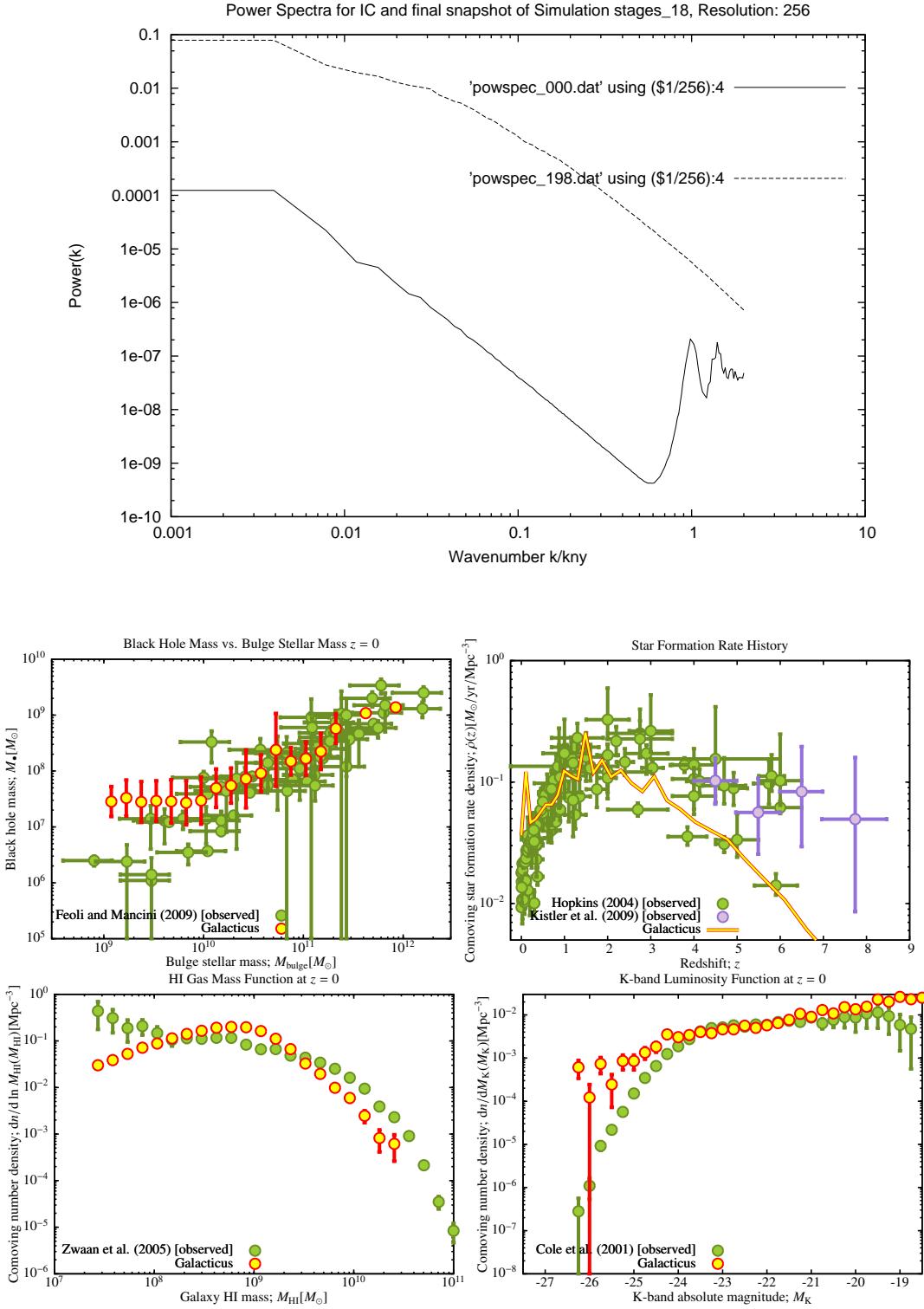
GALACTICUSSED ✓  
CONSISTENTTREED ✓  
ROCKSTARRED ✓

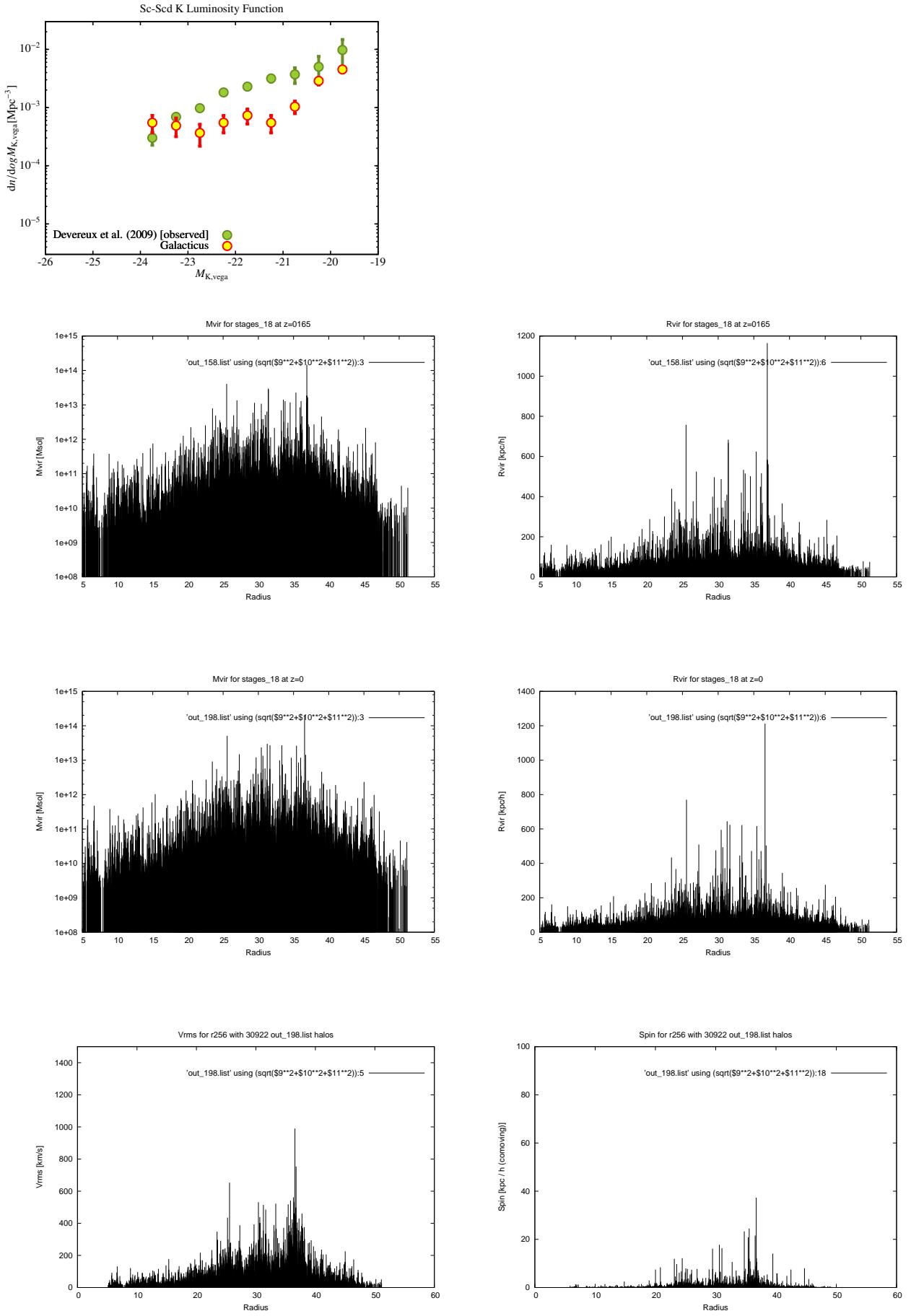
### 2.2.16 stages\_14e



### 2.2.17 stages\_18

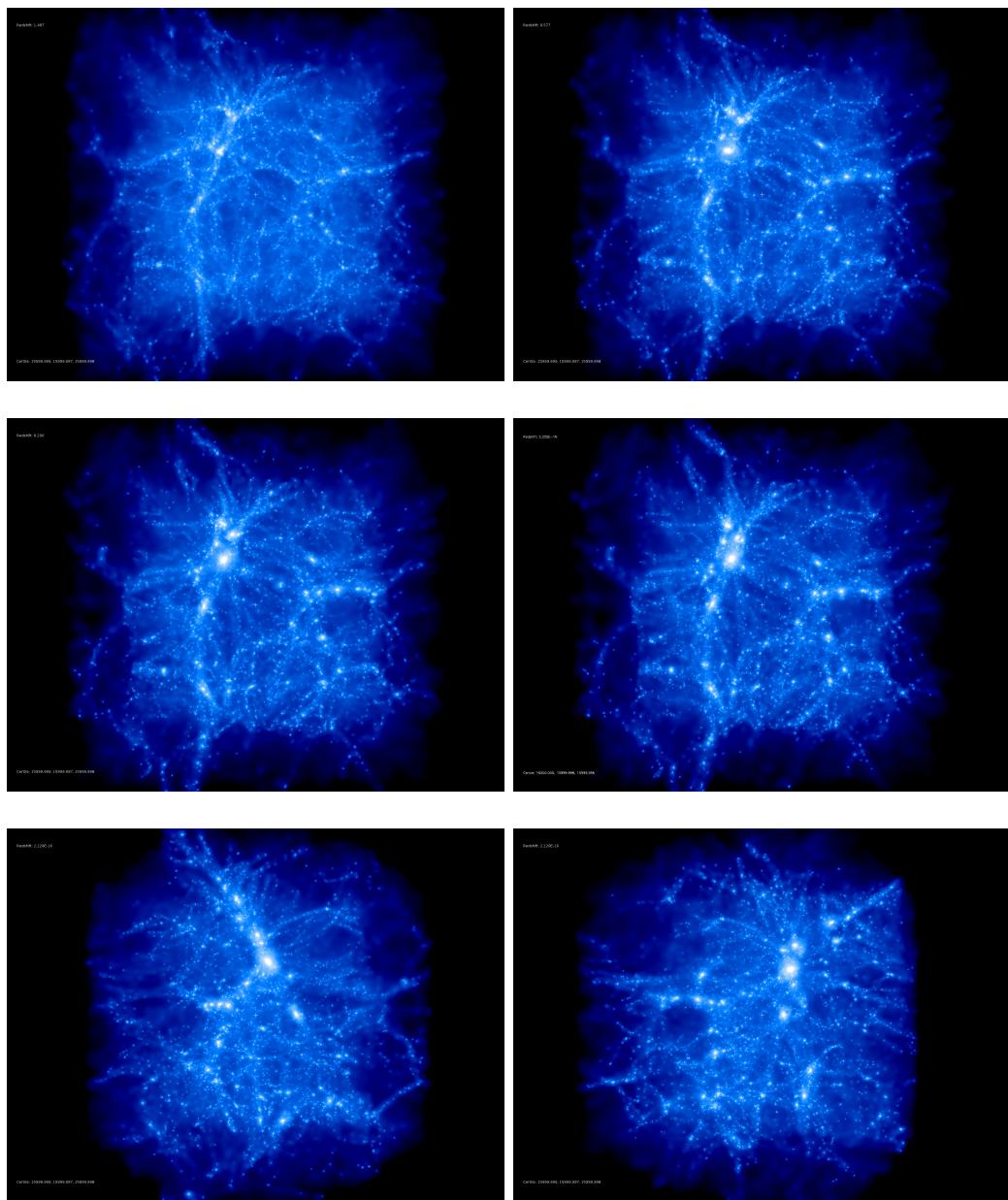


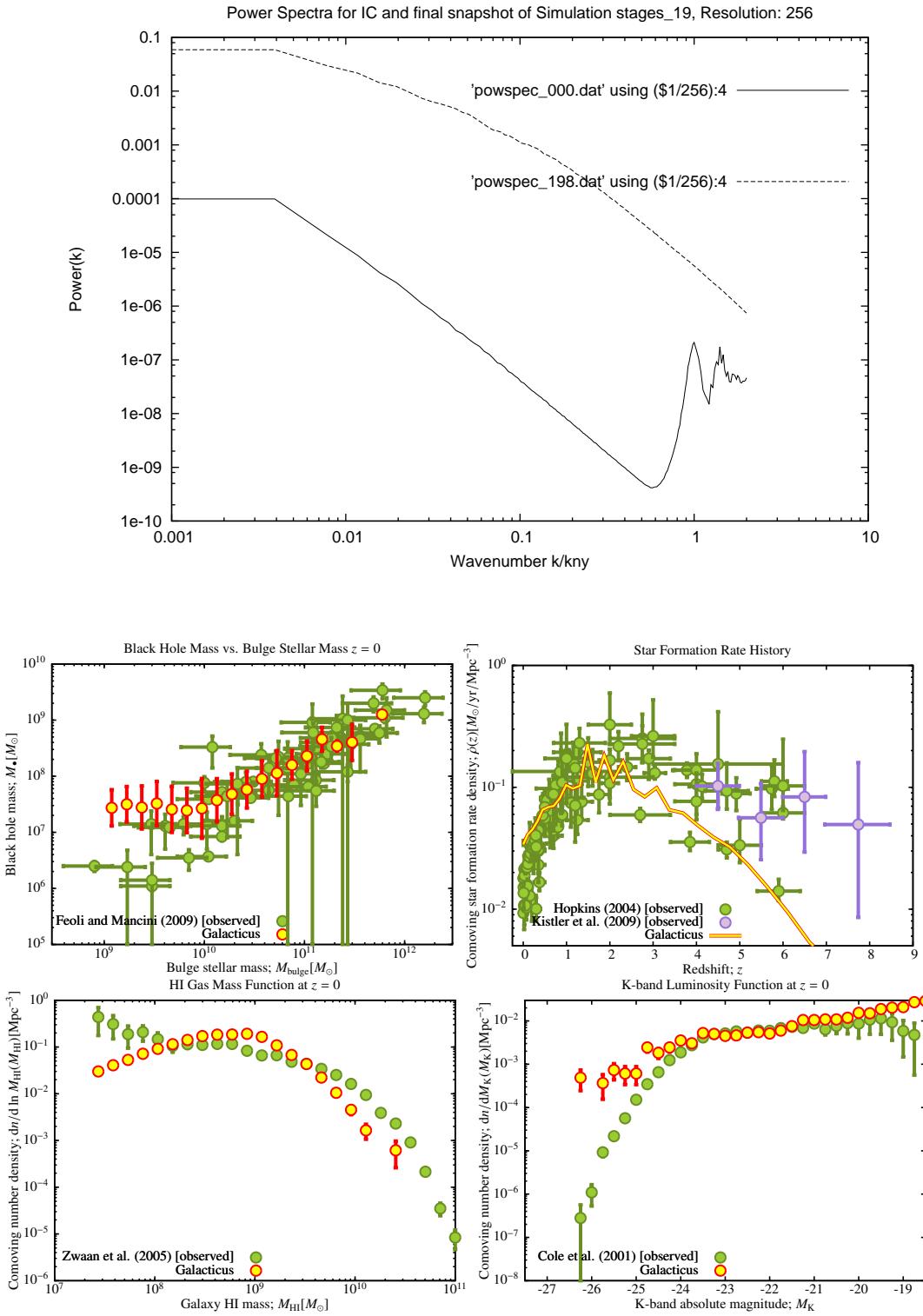


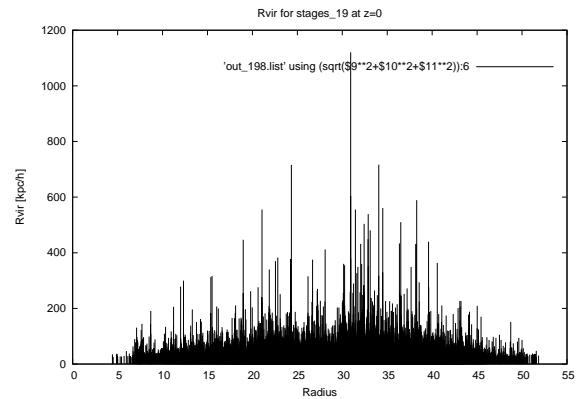
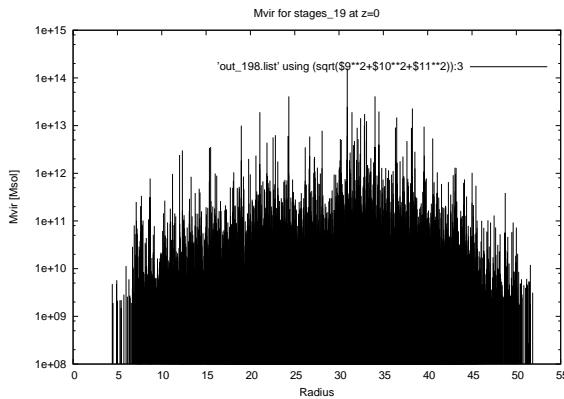
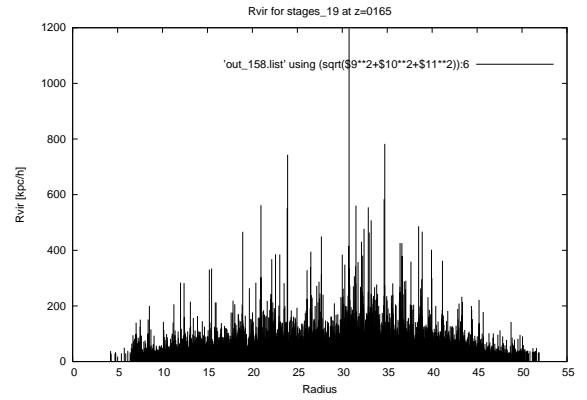
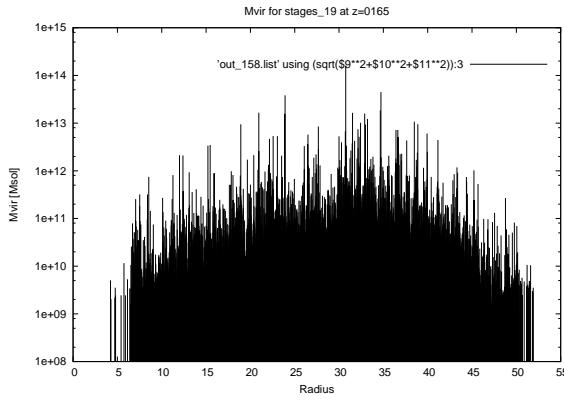
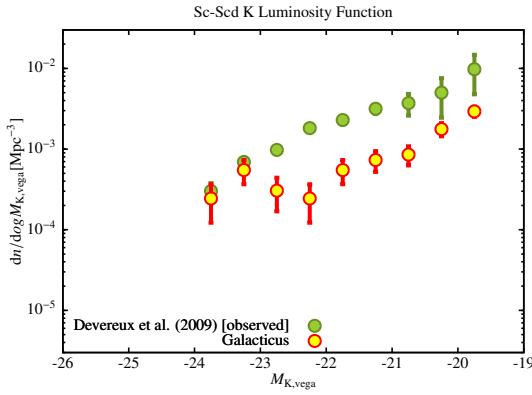


GALACTICUSSED ✓  
CONSISTENTTREED ✓  
ROCKSTARRED ✓

### 2.2.18 stages\_19

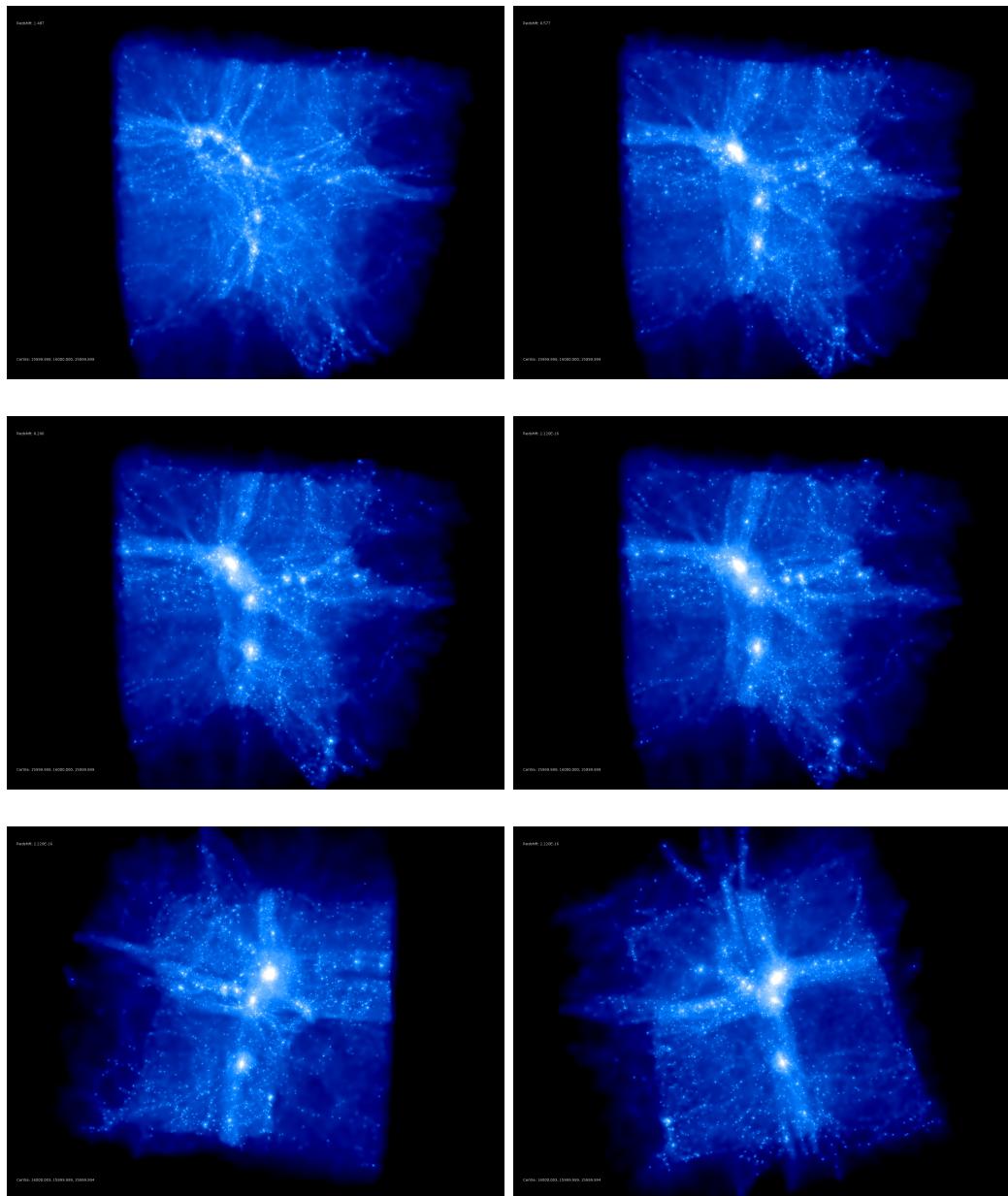


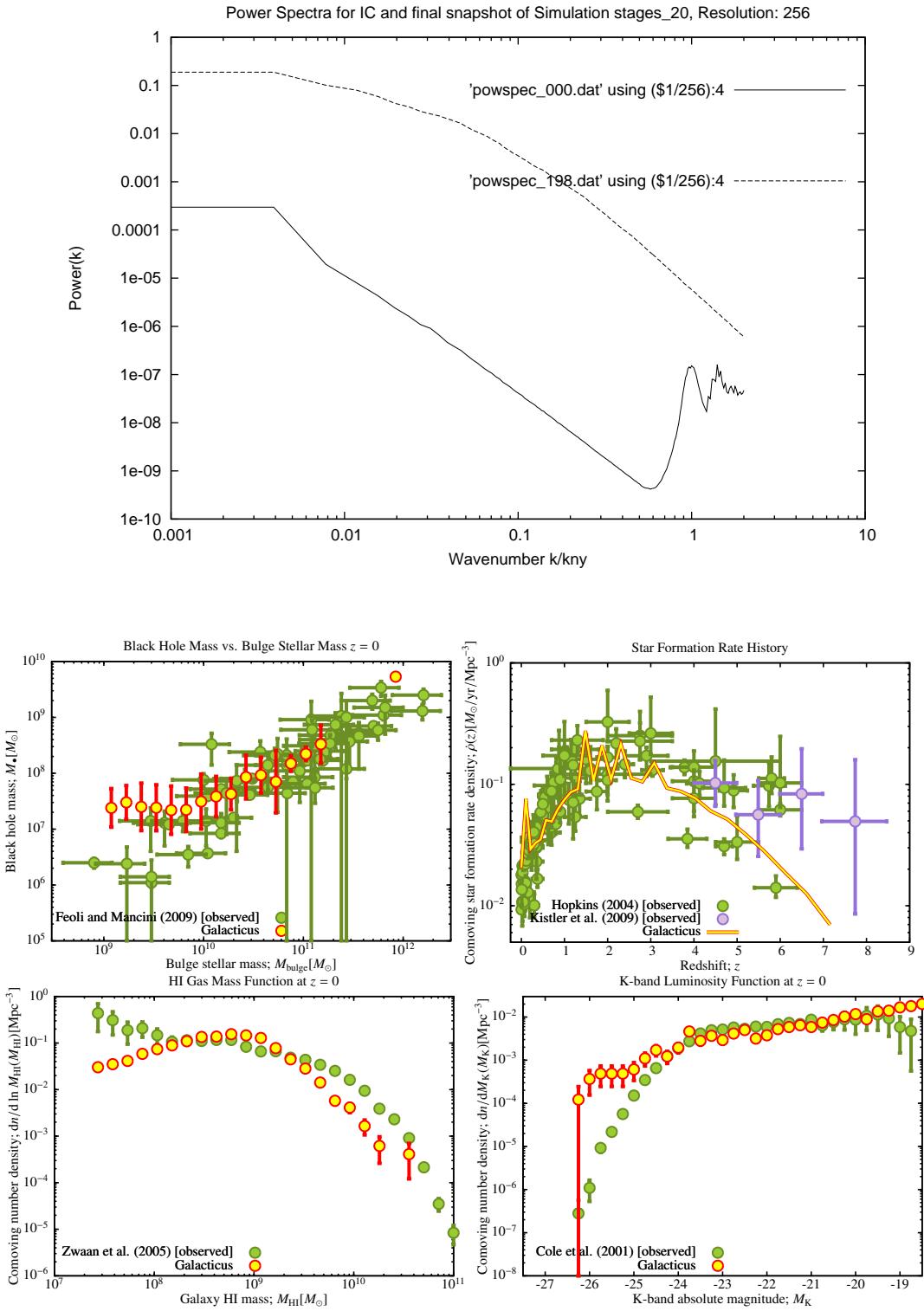


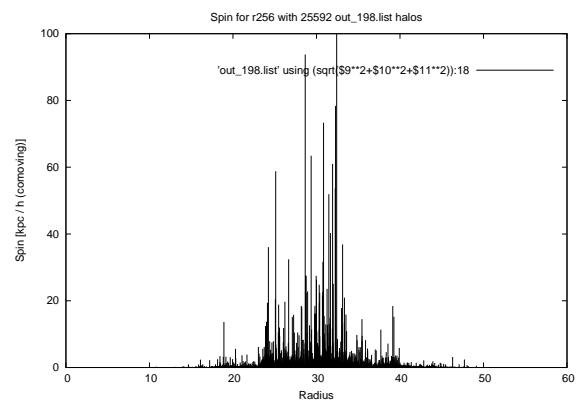
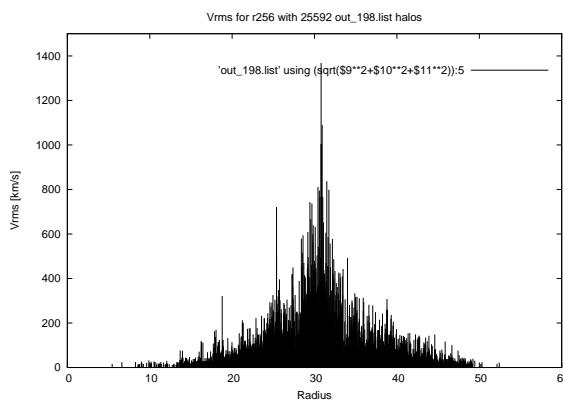
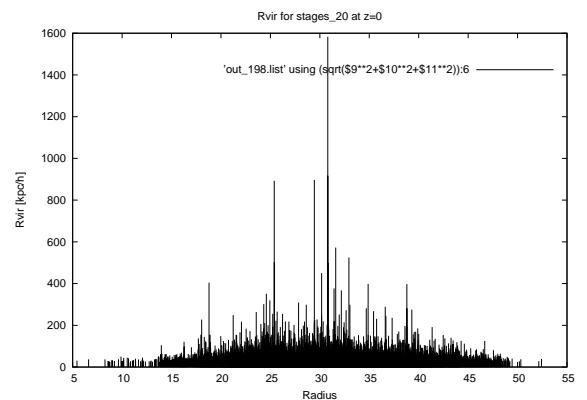
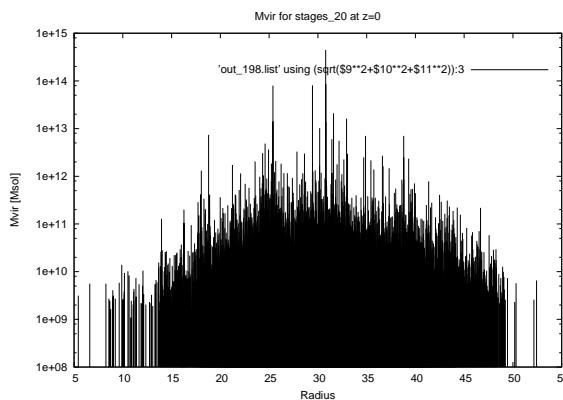
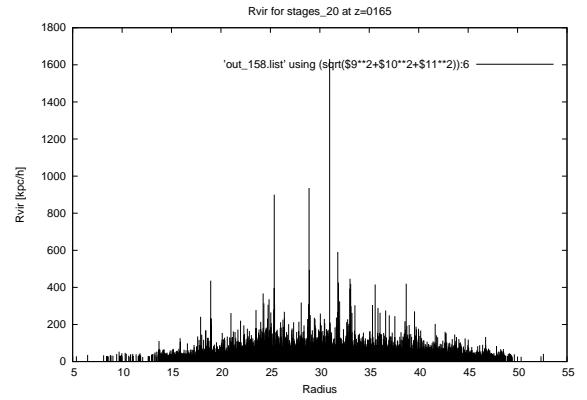
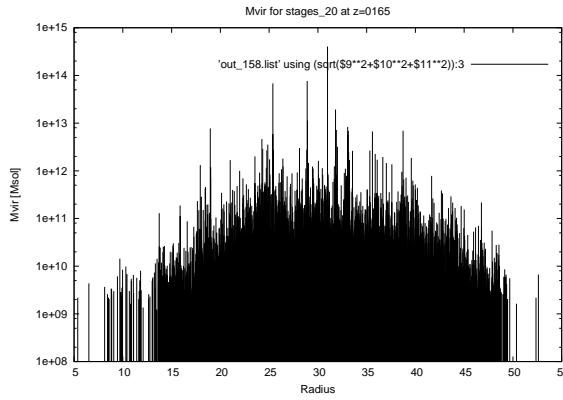
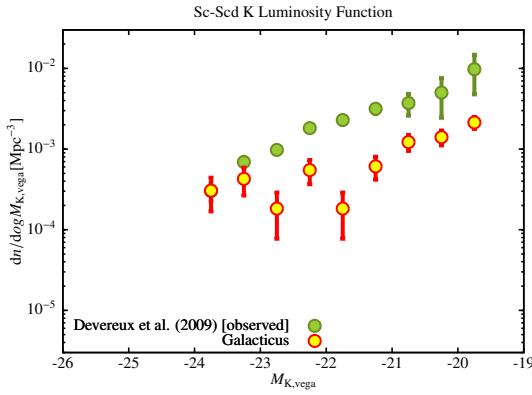


GALACTICUSSED ✓  
 CONSISTENTTREED ✓  
 ROCKSTARRED ✓

### 2.2.19 stages\_20

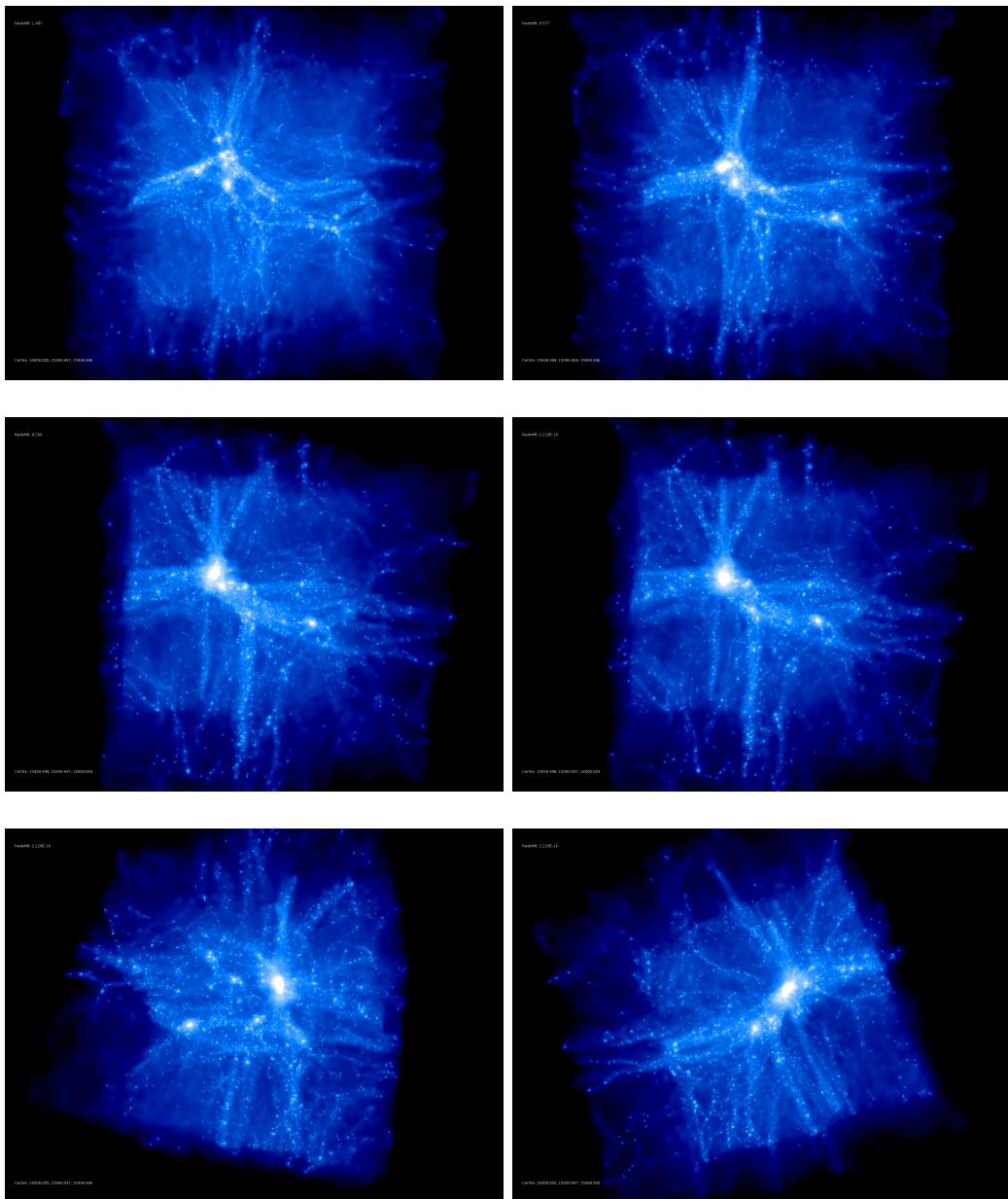


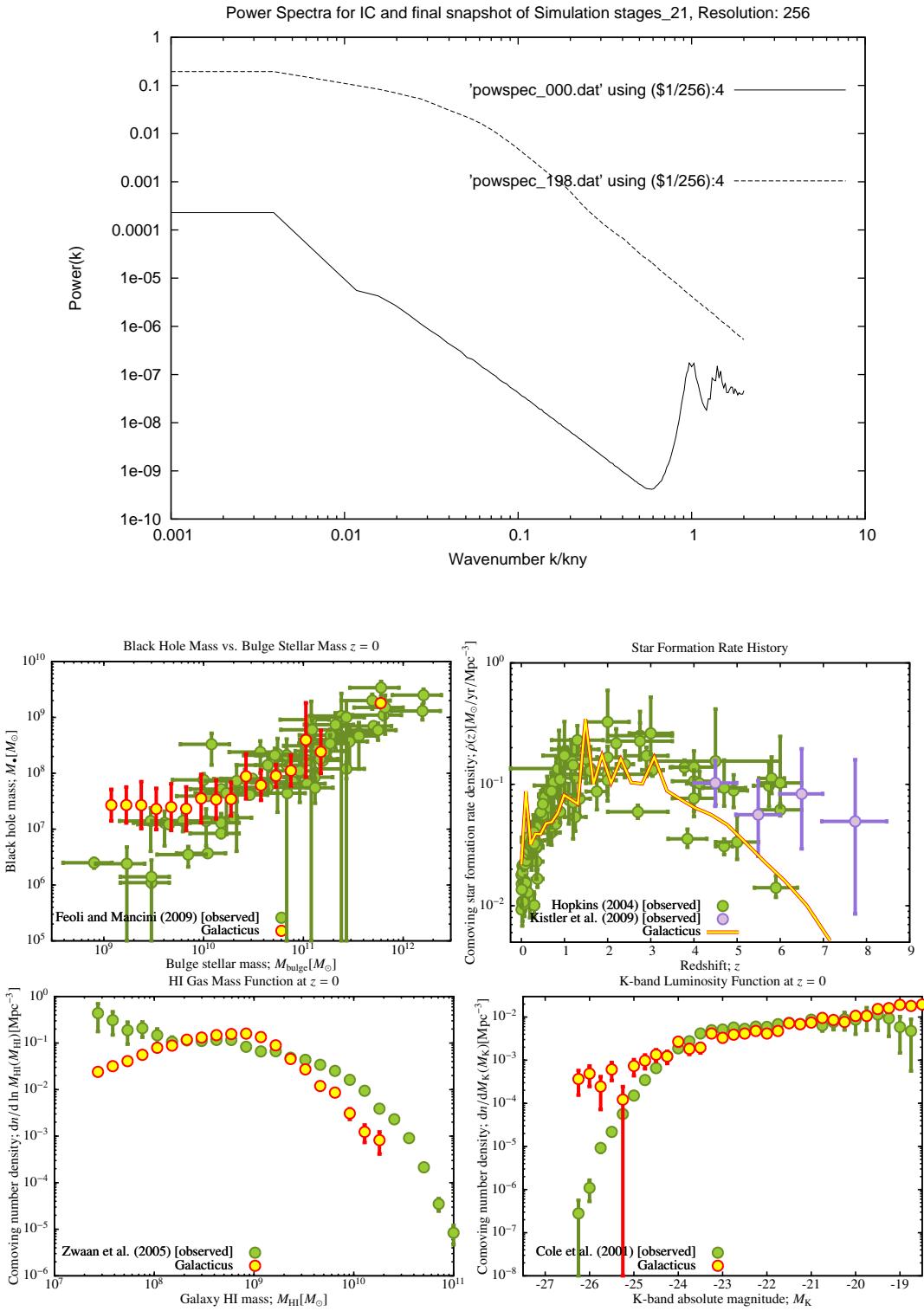


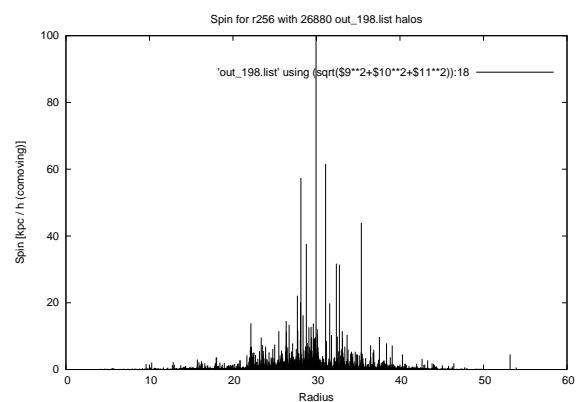
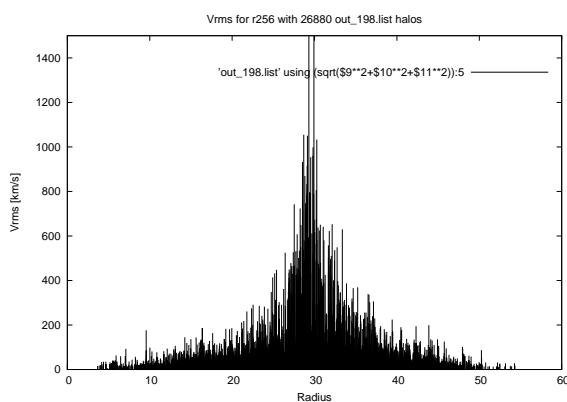
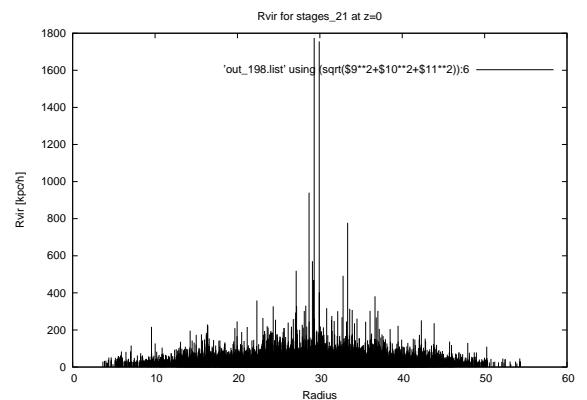
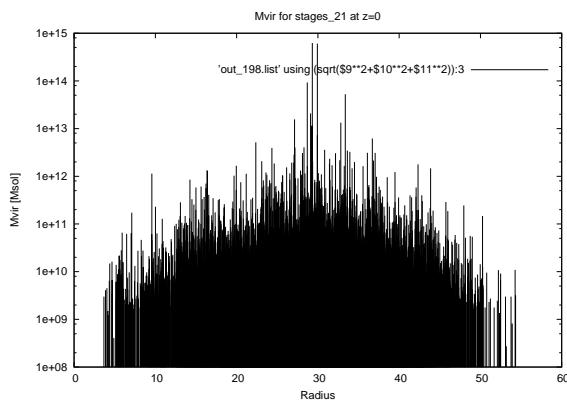
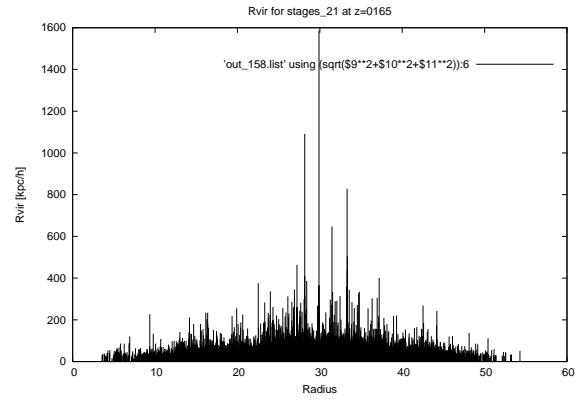
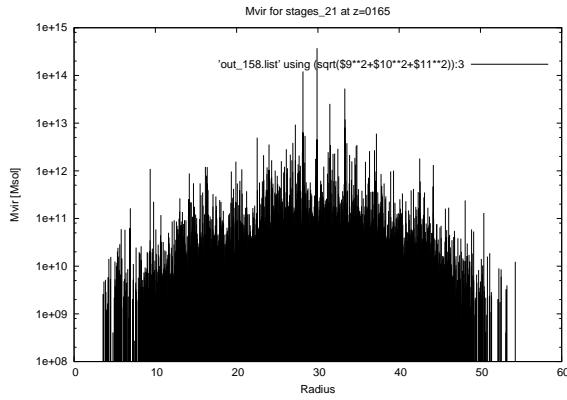
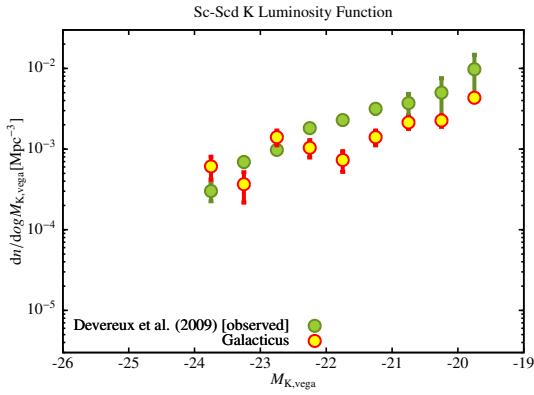


GALACTICUSSED ✓  
CONSISTENTTREED ✓  
ROCKSTARRED ✓

### 2.2.20 stages\_21

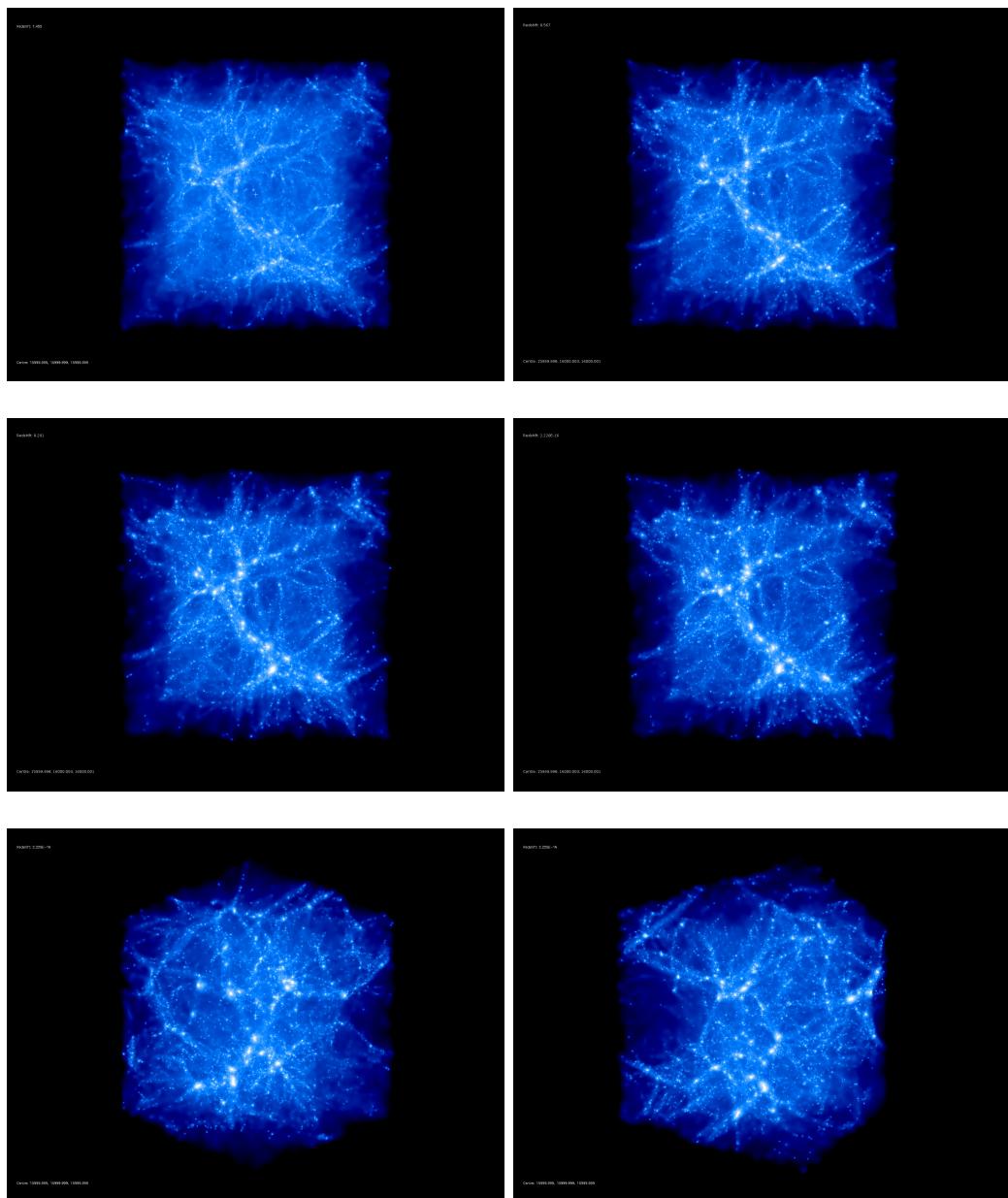


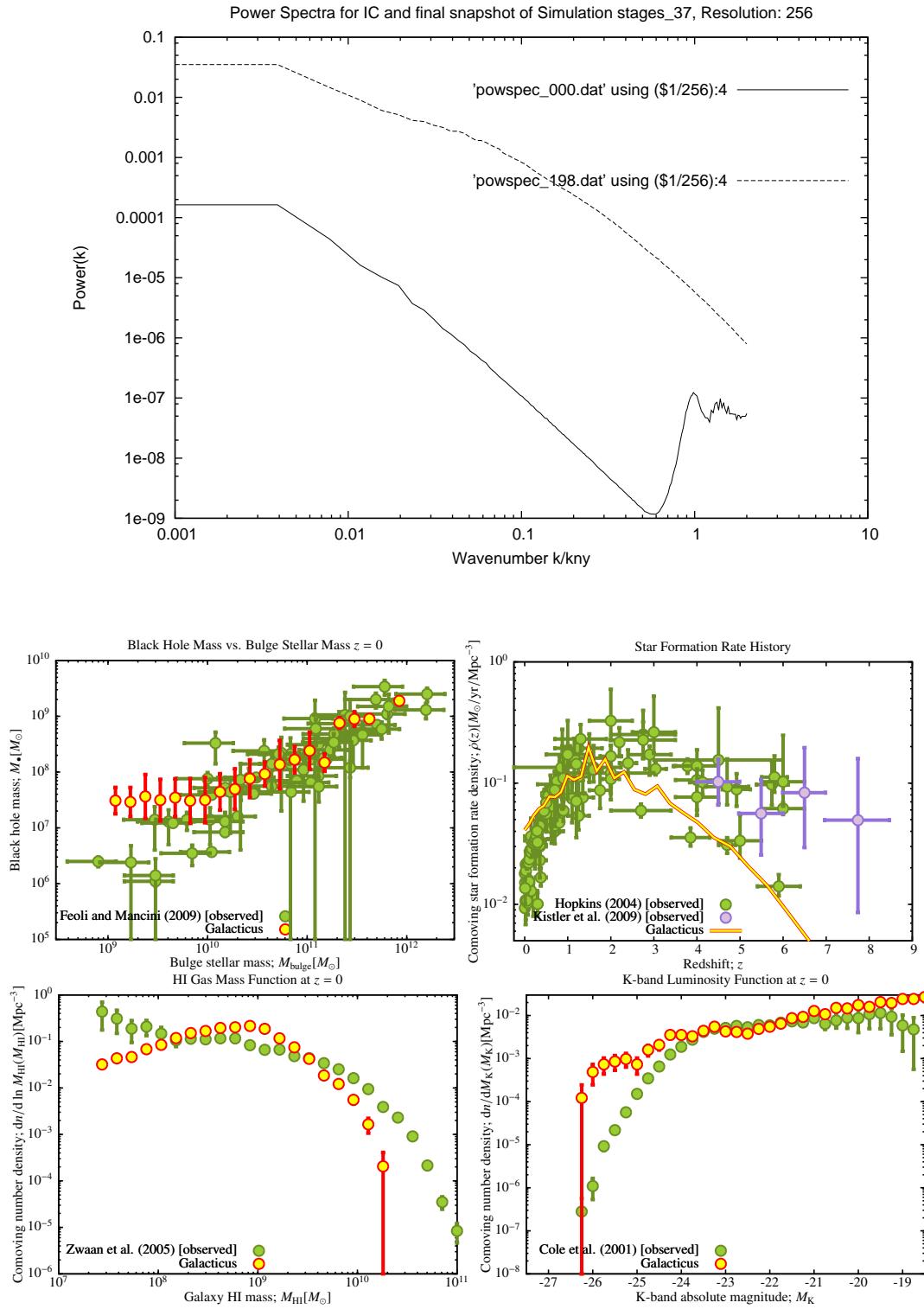


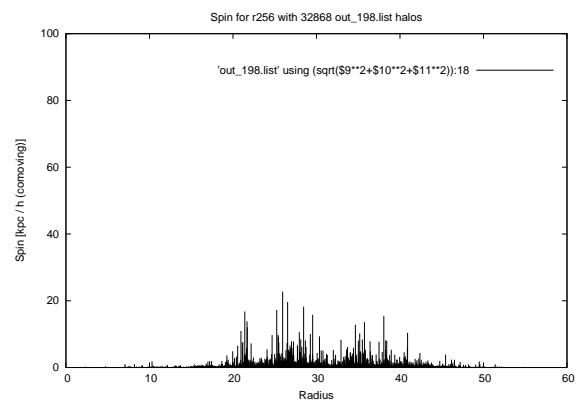
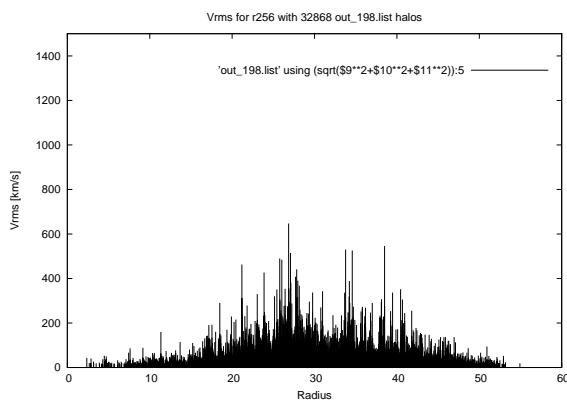
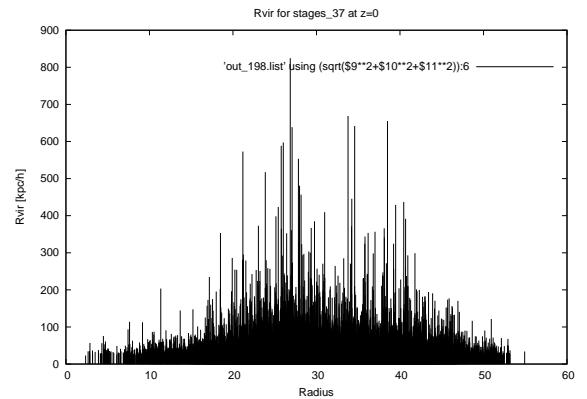
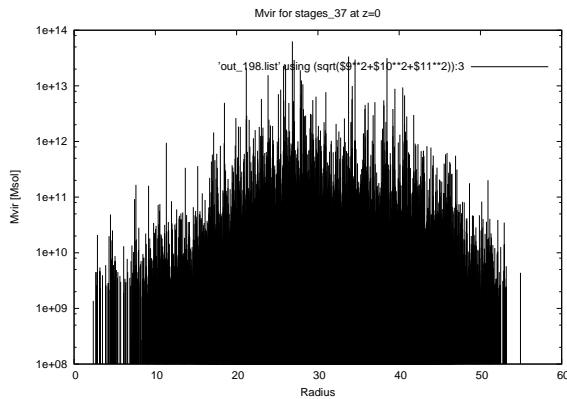
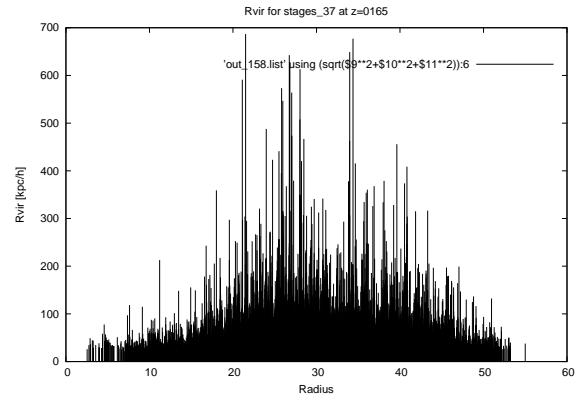
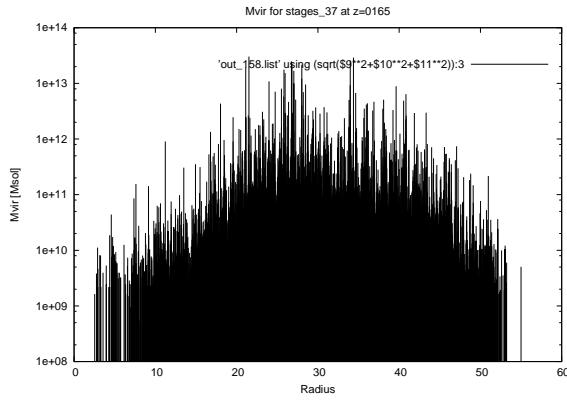
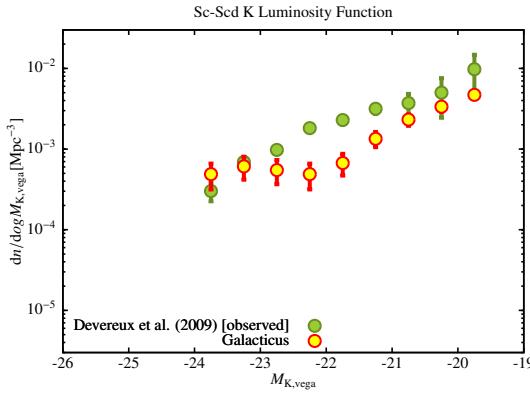


GALACTICUSSED ✓  
CONSISTENTTREED ✓  
ROCKSTARRED ✓

### 2.2.21 stages\_37

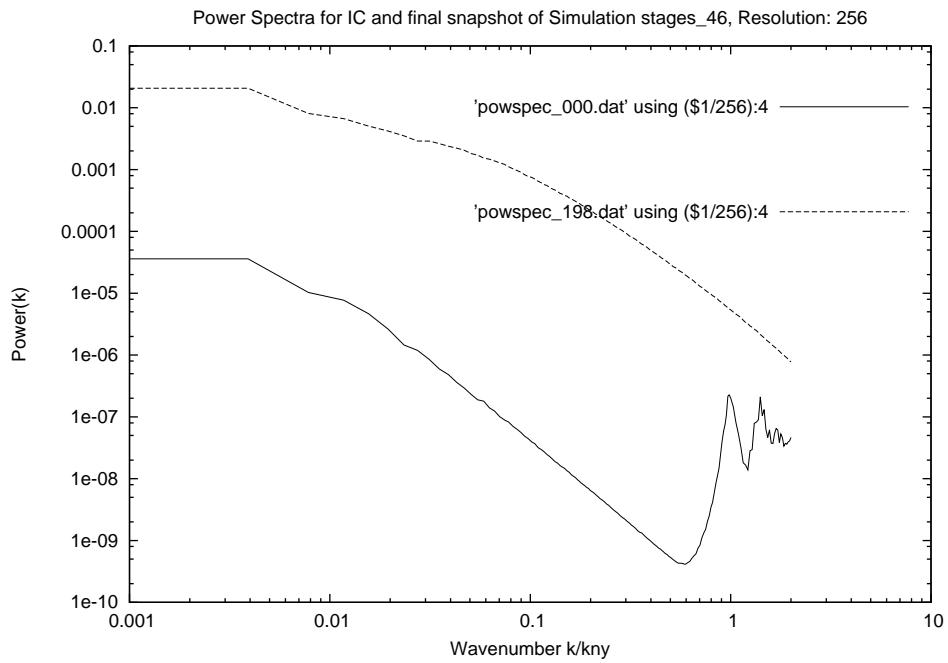




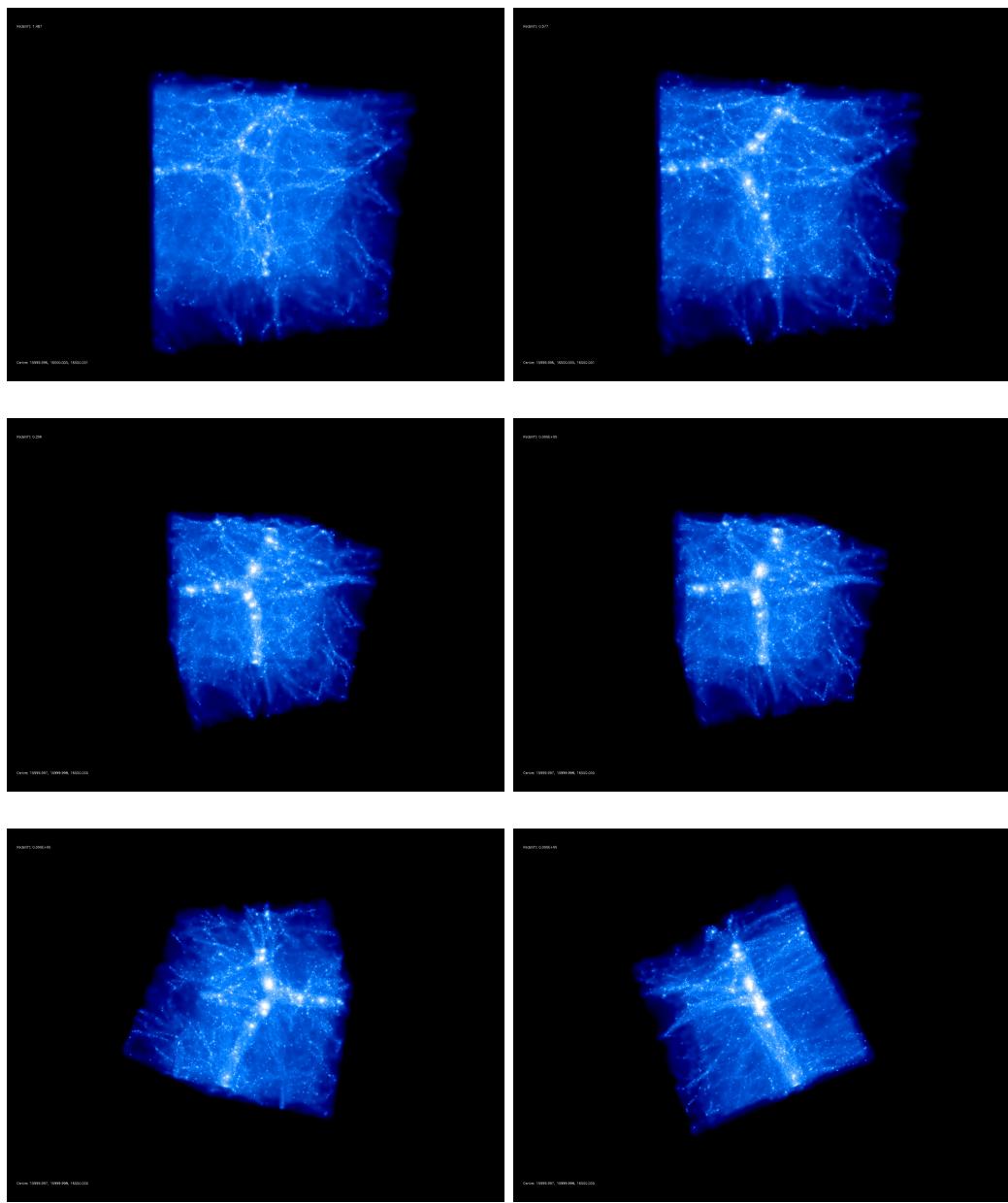


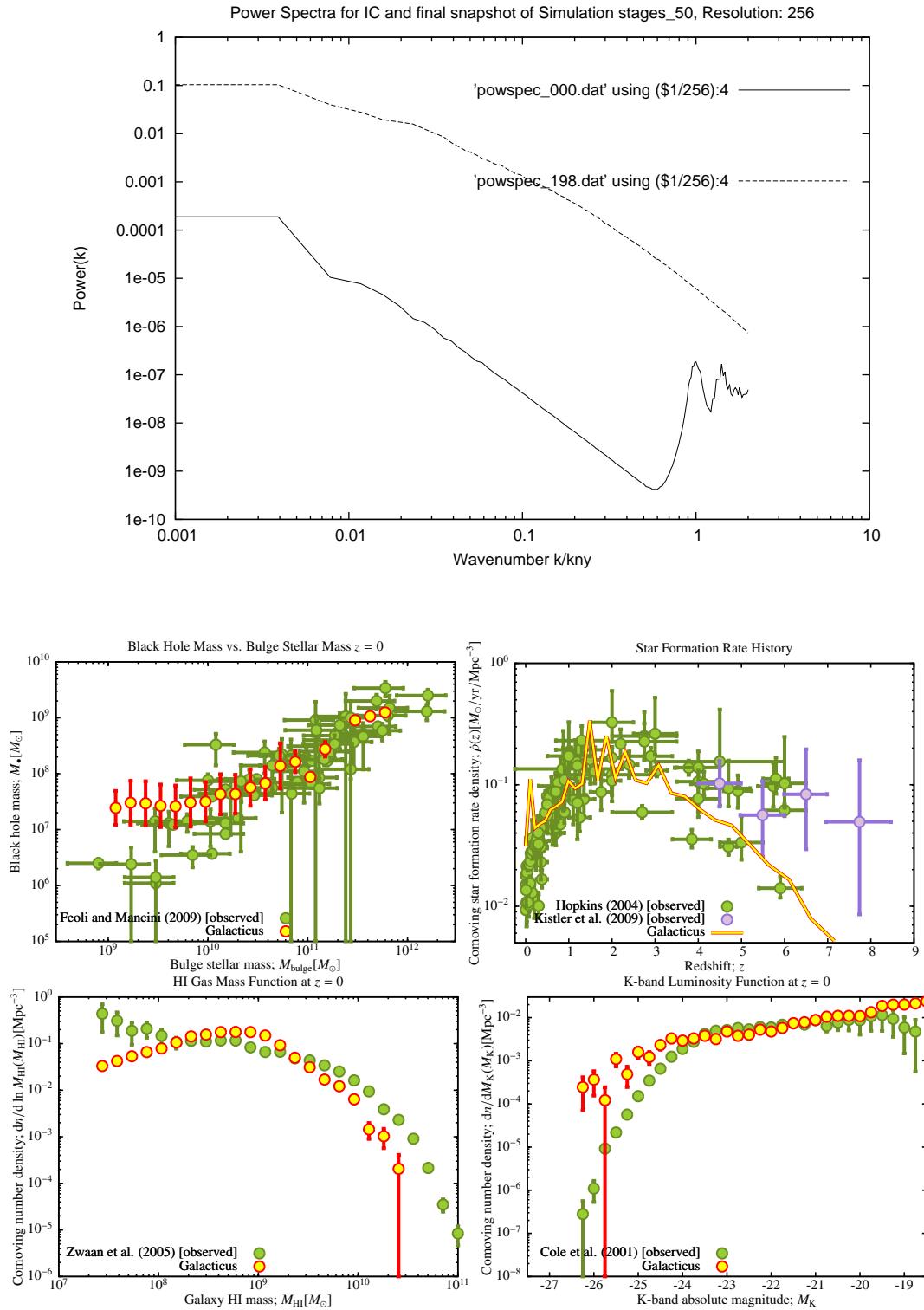
GALACTICUSSED ✓  
CONSISTENTTREED ✓  
ROCKSTARRED ✓

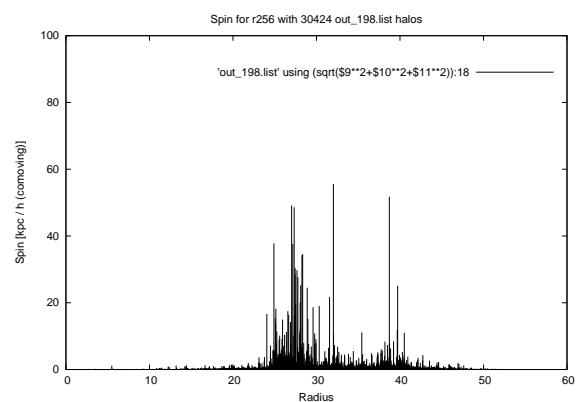
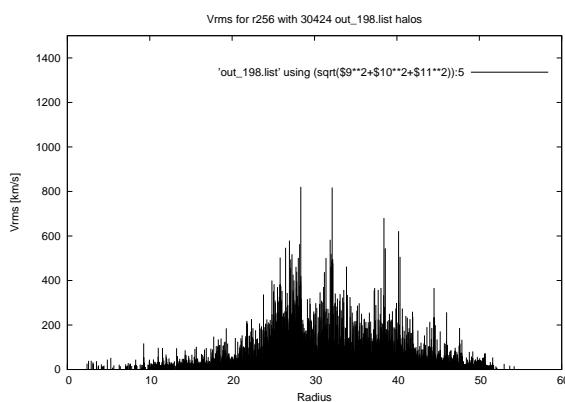
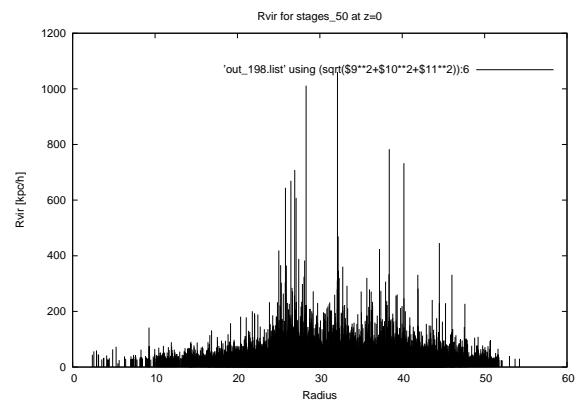
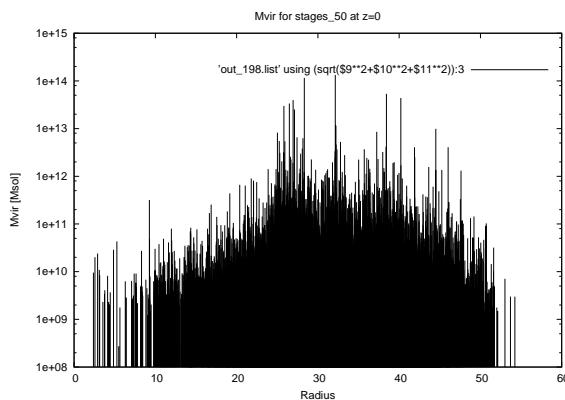
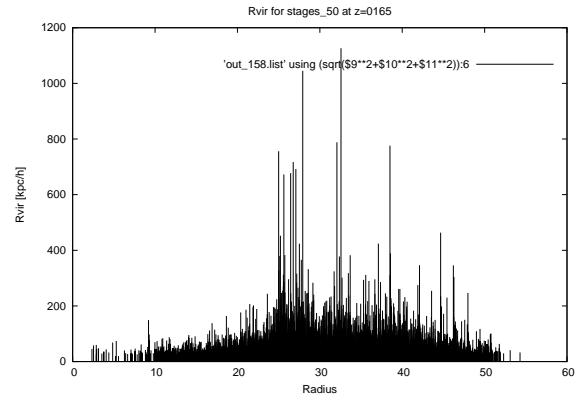
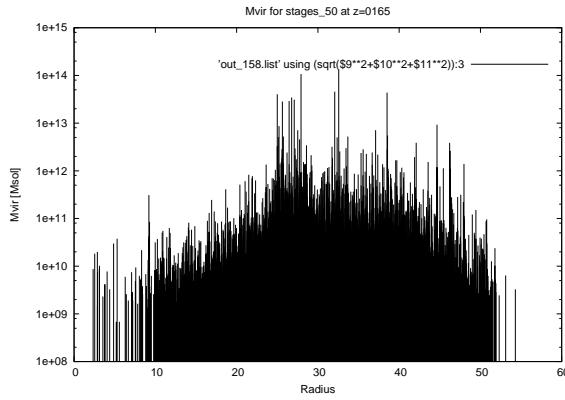
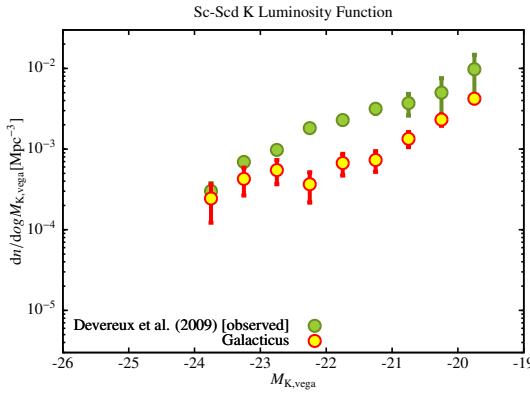
### 2.2.22 stages\_46



### 2.2.23 stages\_50

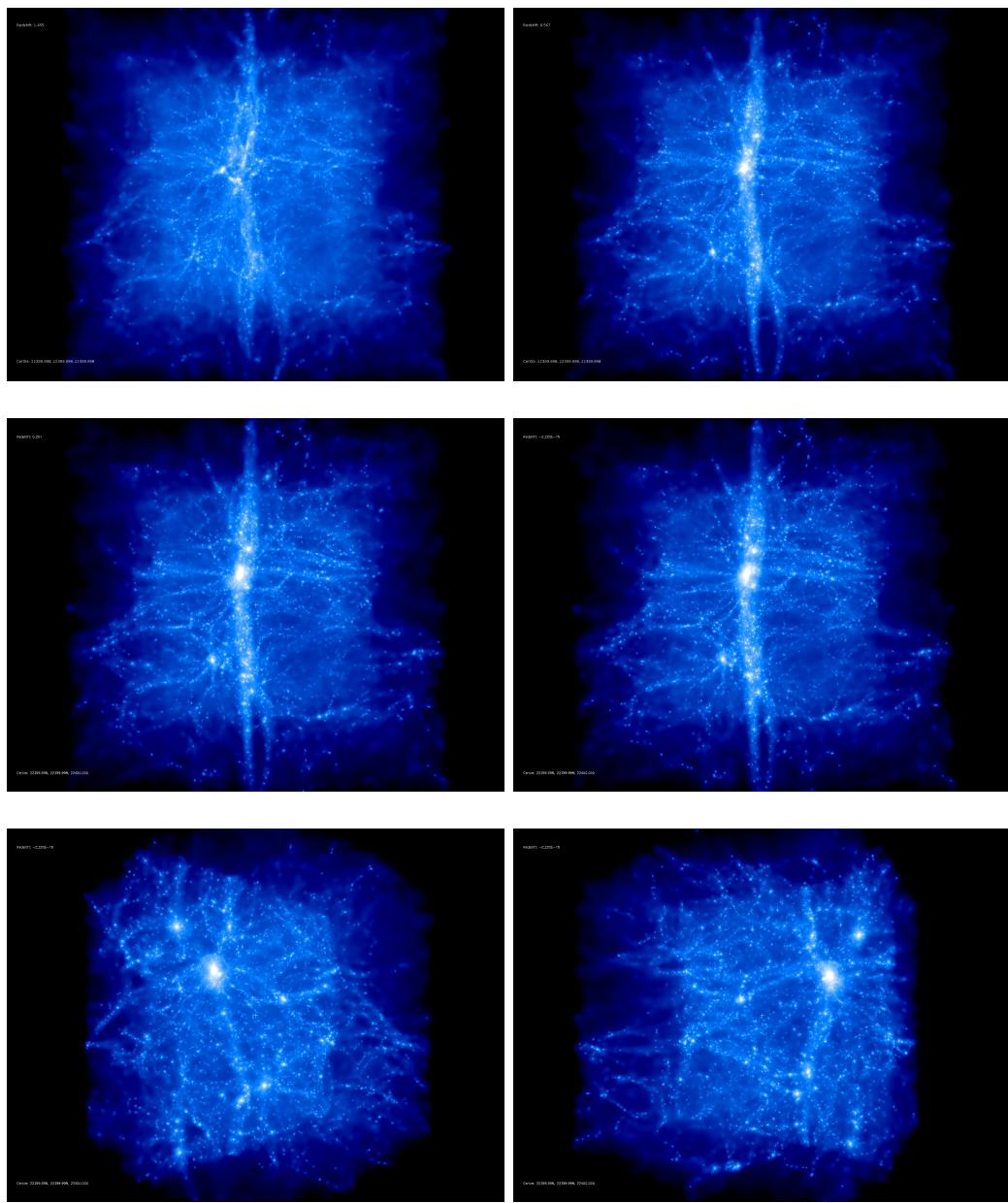


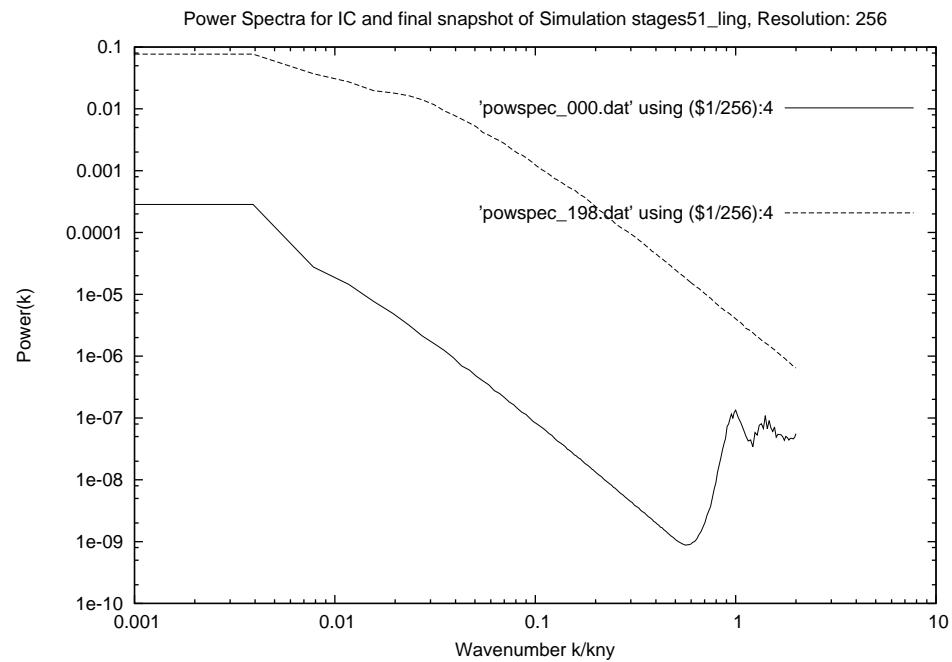




GALACTICUSSED ✓  
CONSISTENTTREED ✓  
ROCKSTARRED ✓

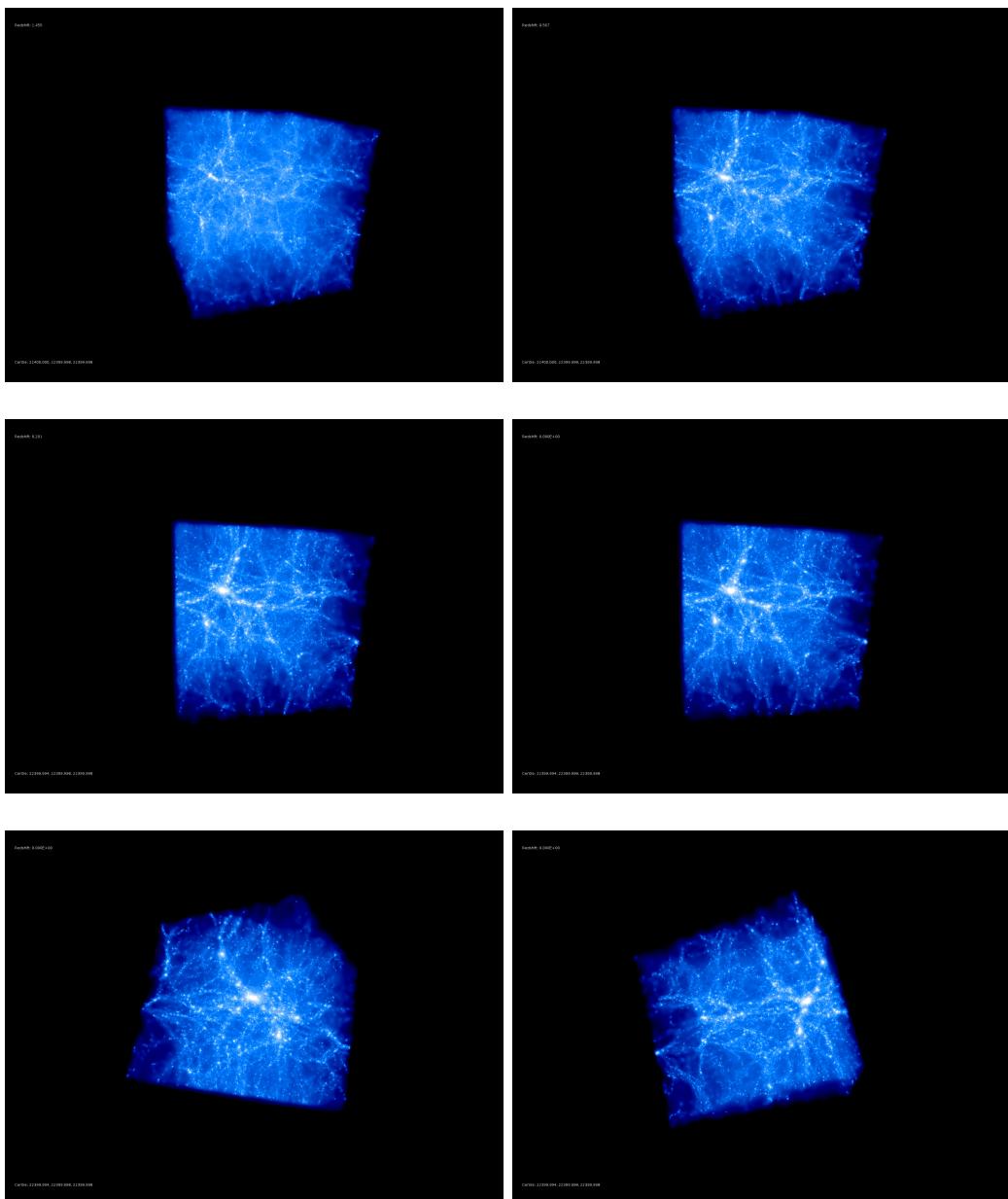
### 2.2.24 stages51\_ling

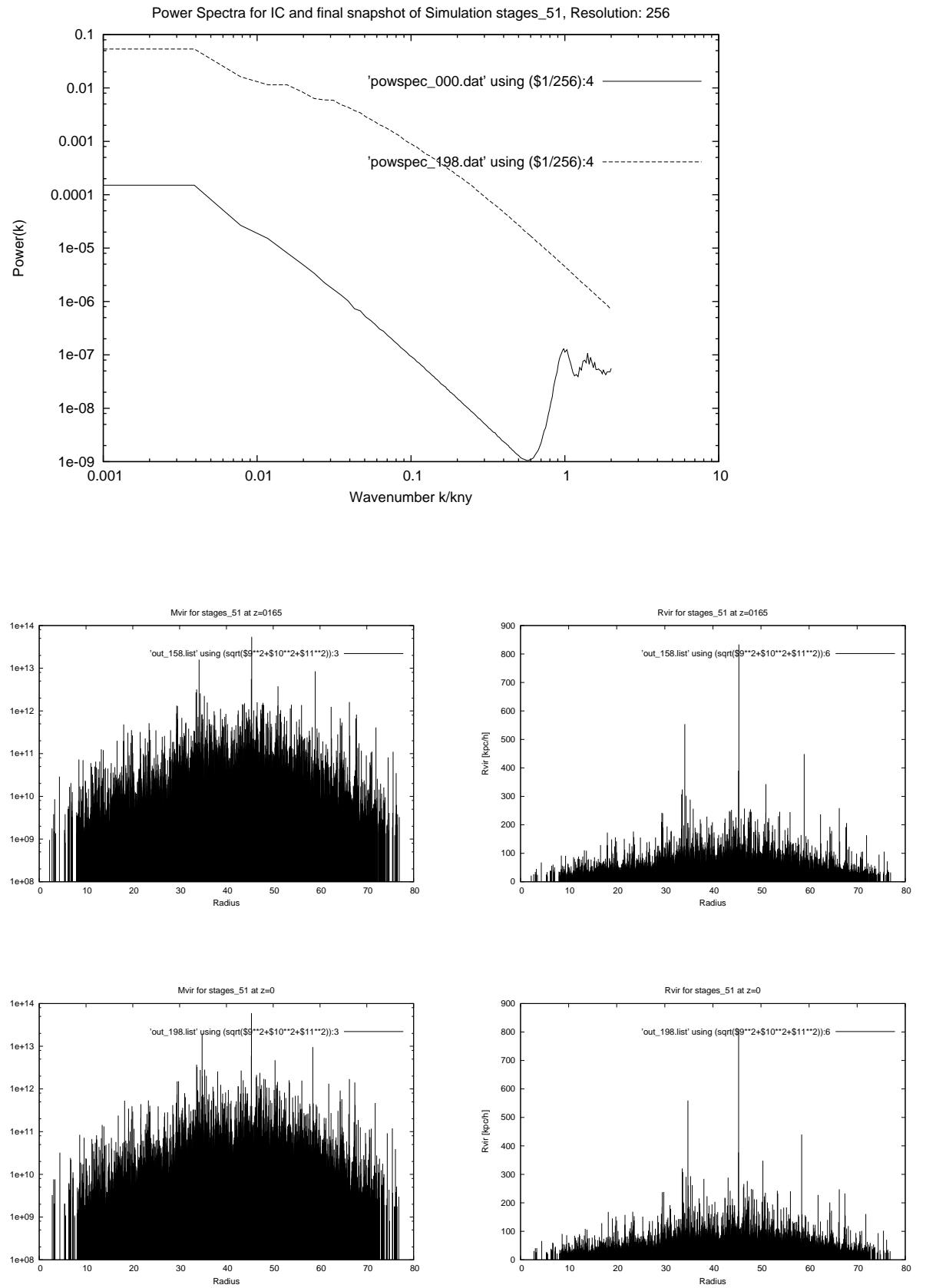


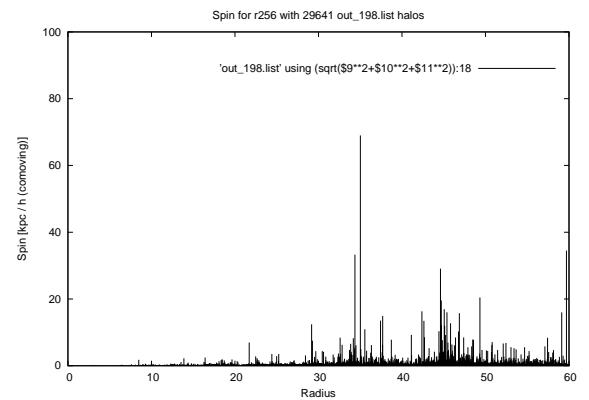
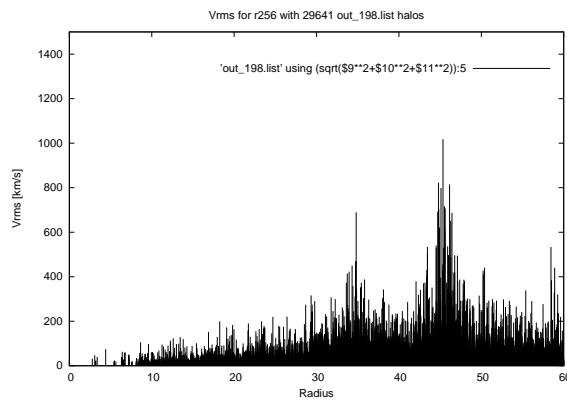


GALACTICUSSED ✓  
CONSISTENTTREE ✓  
ROCKSTARRED ✓

### 2.2.25 stages\_51

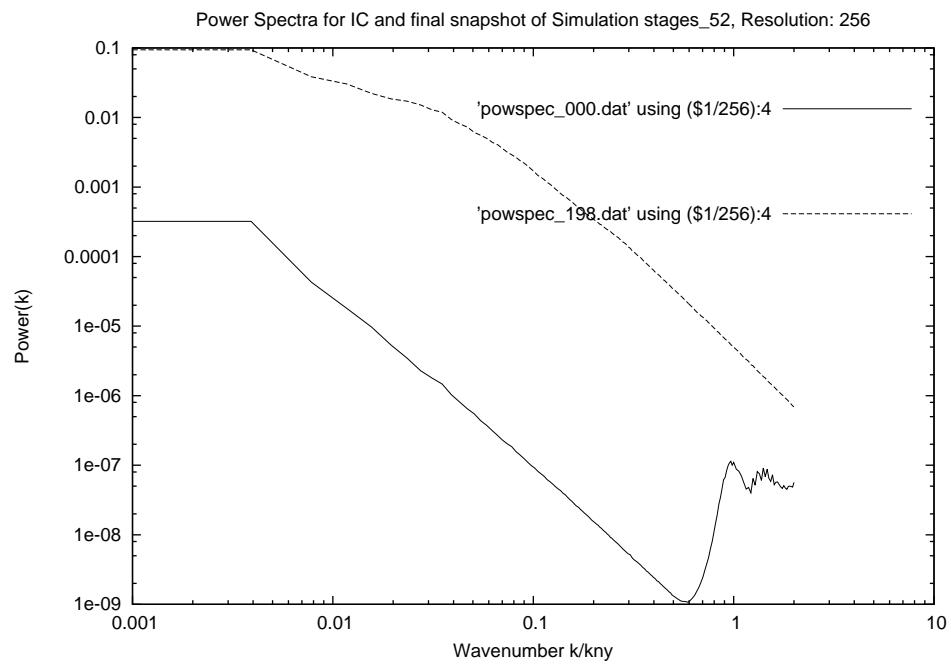






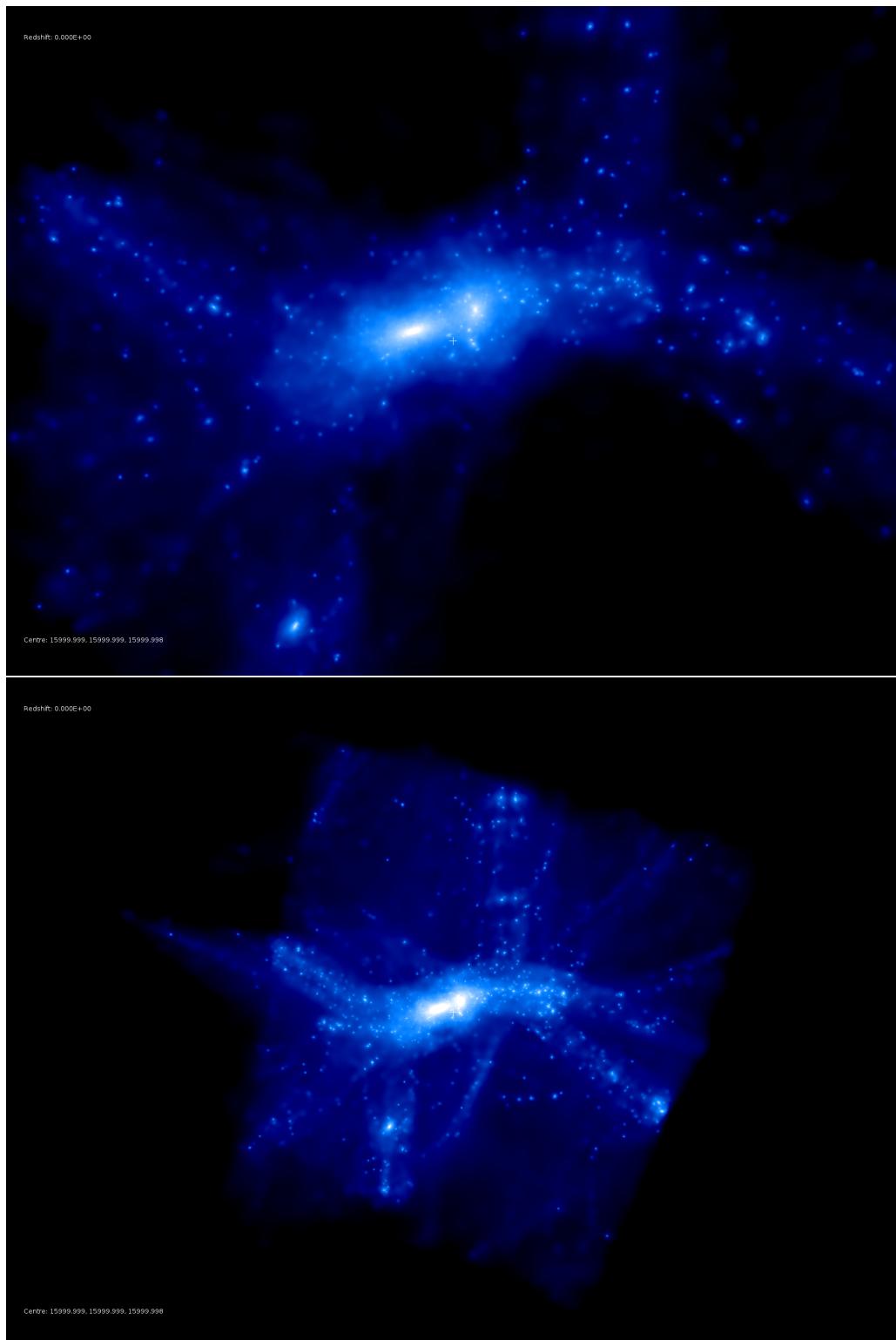
GALACTICUSSED ✓  
CONSISTENTTREEED ✓  
ROCKSTARRED ✓

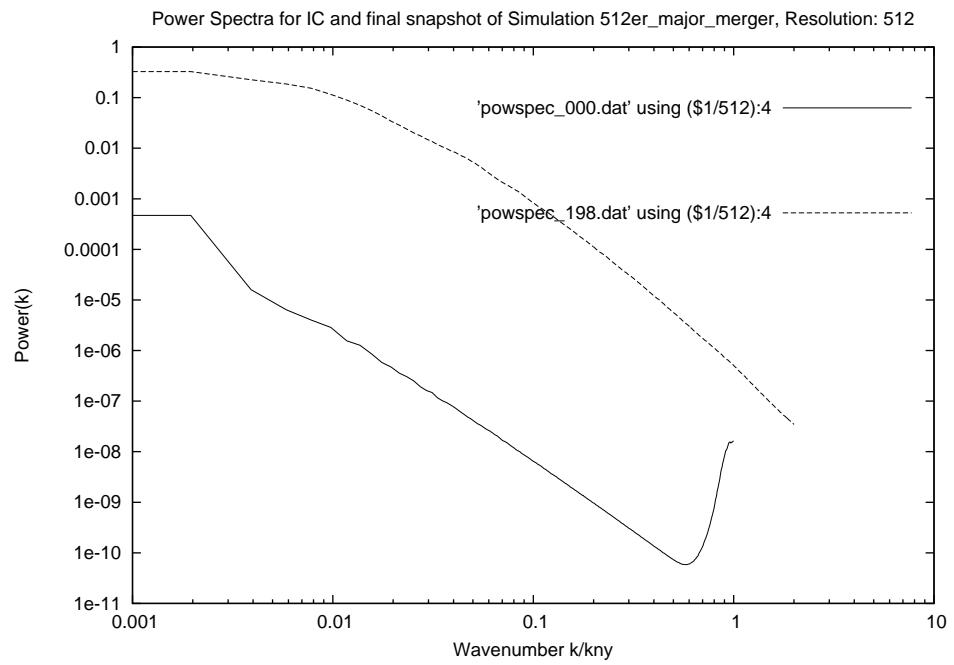
### 2.2.26 stages\_52



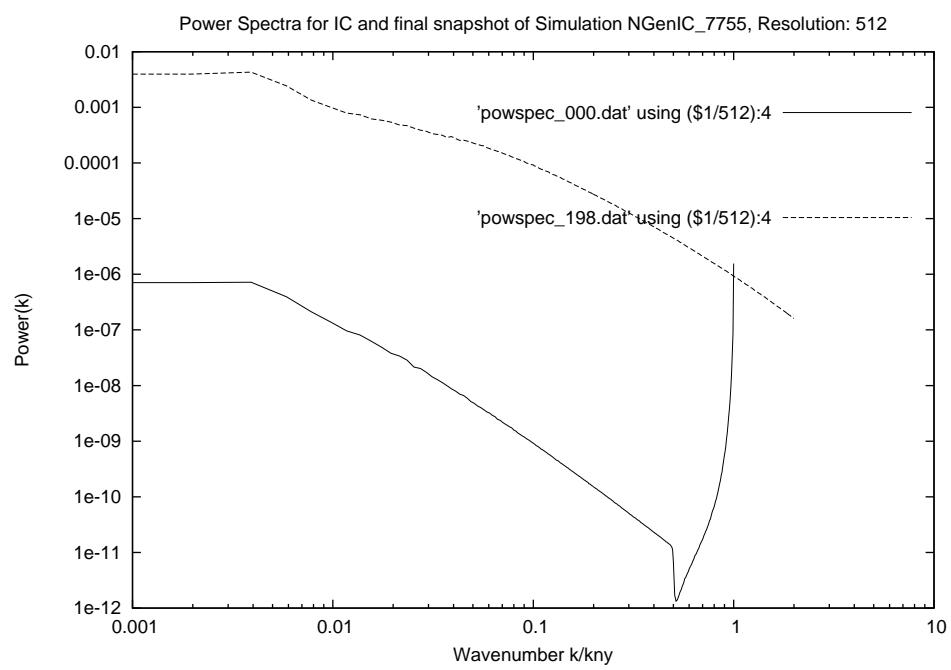
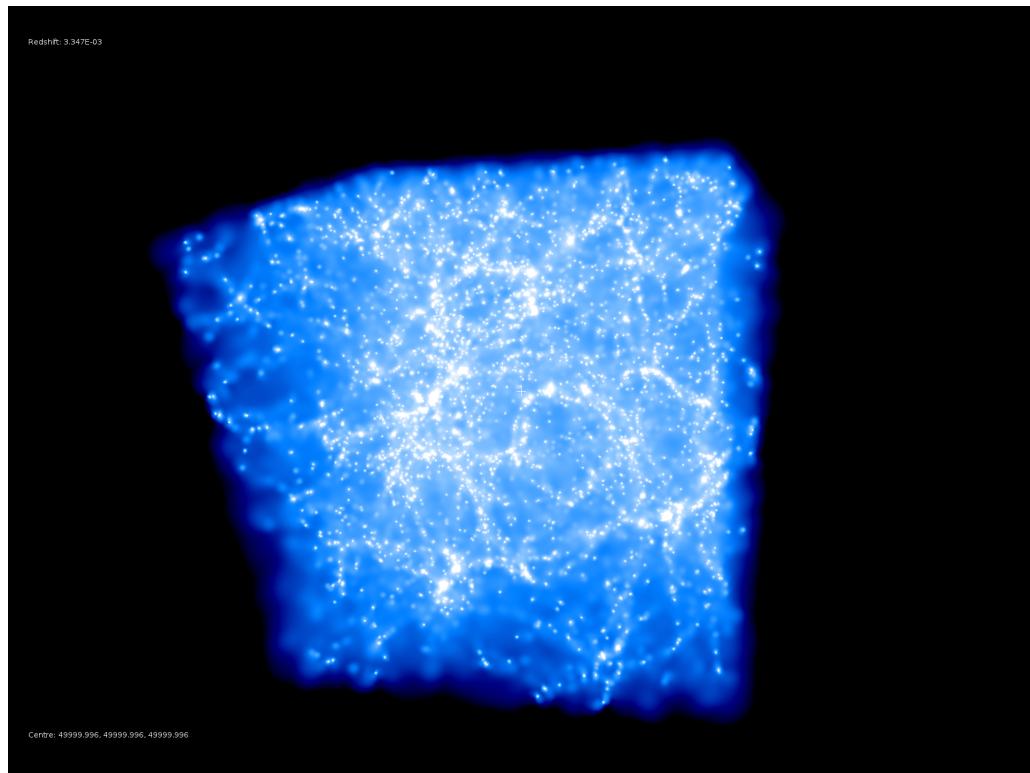
## 2.3 r512

### 2.3.1 512er\_major\_merger

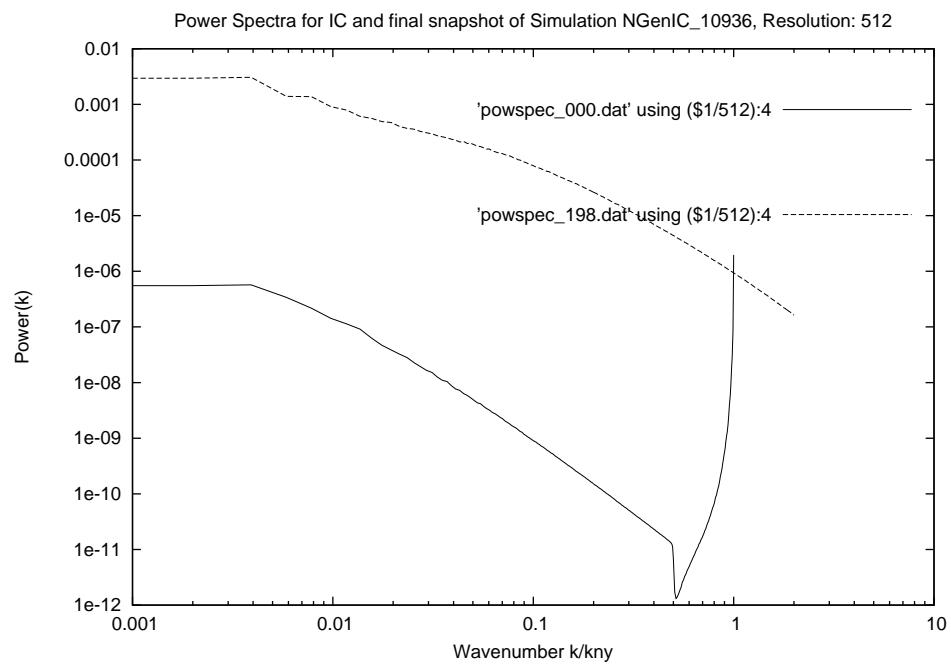




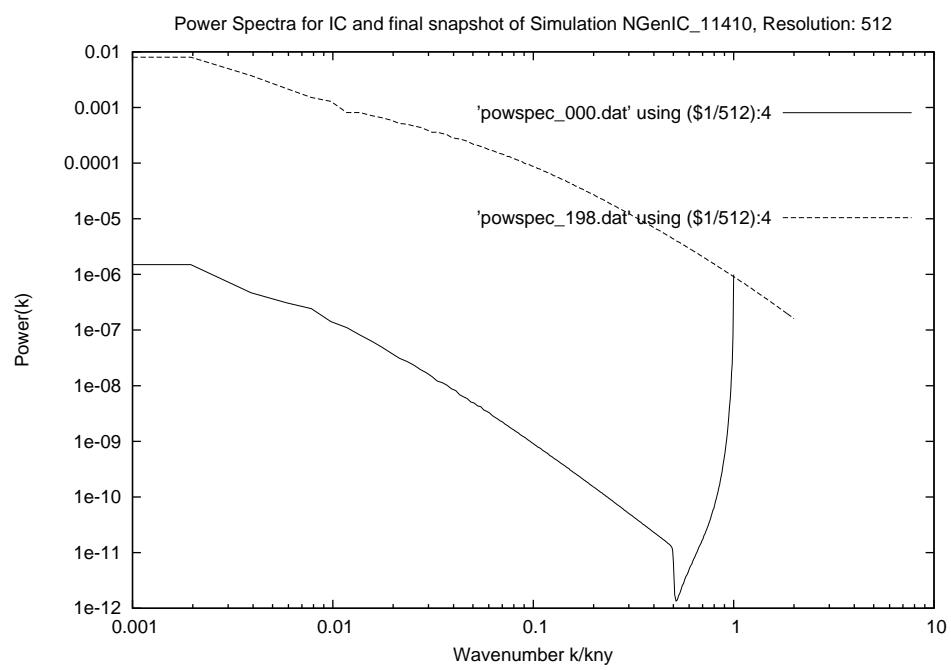
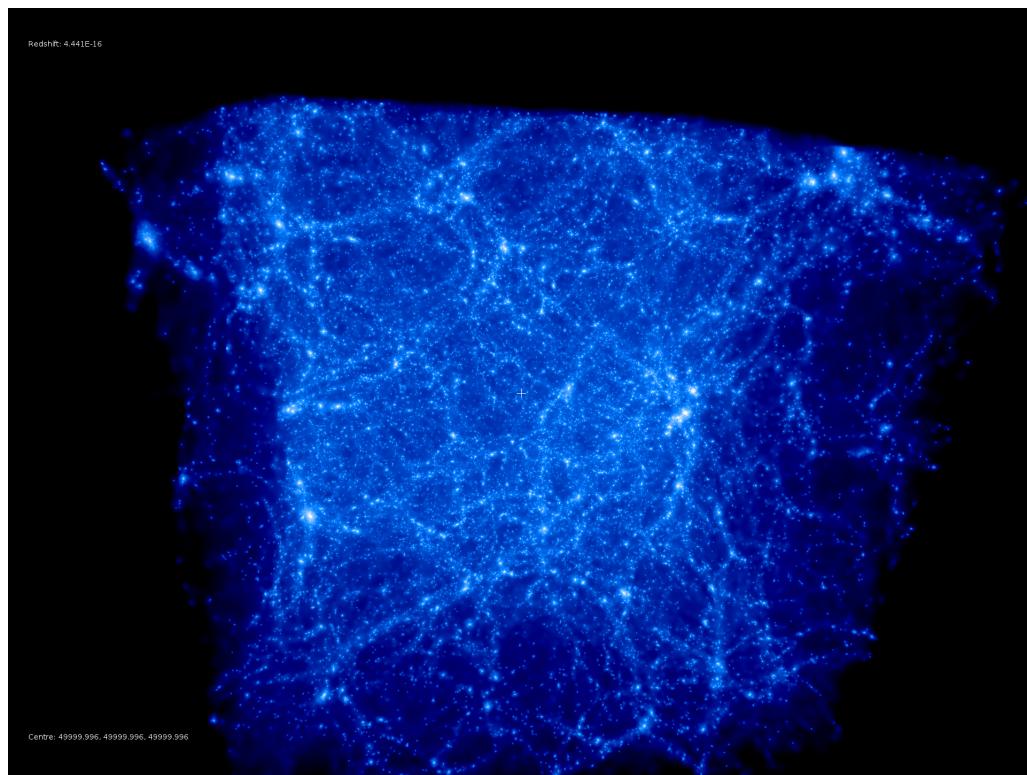
### 2.3.2 NGenIC\_7755



### 2.3.3 NGenIC\_10939



### 2.3.4 NGenIC\_11410



### 2.3.5 NGenIC\_27036

