

01 - Initial Plots

September 11, 2022

```
[1]: import pandas as pd
import matplotlib.pyplot as plt
import numpy as np

# Read in CSV
df_o = pd.read_csv('halo_catalogue_organic.txt', '\t')
df_e = pd.read_csv('halo_catalogue_gm_early.txt', '\t')
df_l = pd.read_csv('halo_catalogue_gm_late.txt', '\t')

with pd.option_context('display.max_rows', None):
    display(df_o)
    display(df_e)
    display(df_l)
```

```
C:\Users\jkrob\AppData\Local\Programs\Python\Python39\lib\site-
packages\IPython\core\interactiveshell.py:3251: FutureWarning: In a future
version of pandas all arguments of read_csv except for the argument
'filepath_or_buffer' will be keyword-only.
```

```
exec(code_obj, self.user_global_ns, self.user_ns)
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```

```
exec(code_obj, self.user_global_ns, self.user_ns)
```

	index	time [Gyr]	a_exp	redshift	subhalo centre x [Mpc]	\
0	2	0.476	0.091	9.993	4.048	
1	3	0.550	0.100	8.988	4.454	
2	4	0.635	0.110	8.075	4.900	
3	5	0.760	0.124	7.050	5.600	
4	6	0.942	0.143	5.971	6.364	
5	7	1.049	0.154	5.487	6.935	
6	8	1.168	0.166	5.037	7.448	
7	9	1.348	0.182	4.485	8.070	

8	10	1.556	0.201	3.984	8.877
9	11	1.795	0.221	3.528	9.762
10	12	2.144	0.249	3.017	11.132
11	13	2.653	0.287	2.478	12.856
12	14	2.949	0.309	2.237	13.788
13	15	3.276	0.332	2.012	14.766
14	16	3.767	0.365	1.737	16.206
15	17	4.325	0.402	1.487	17.754
16	18	4.958	0.443	1.259	19.418
17	19	5.864	0.499	1.004	21.709
18	20	6.472	0.536	0.865	23.286
19	21	7.131	0.576	0.736	24.988
20	22	7.841	0.619	0.615	26.753
21	23	8.603	0.665	0.503	28.627
22	24	9.698	0.732	0.366	31.366
23	25	10.577	0.787	0.271	33.577
24	26	11.501	0.846	0.183	35.951
25	27	12.469	0.909	0.101	38.492
26	28	13.821	1.000	0.000	42.109

	subhalo centre y [Mpc]	subhalo centre z [Mpc]	\
0	0.730	3.345	
1	0.799	3.673	
2	0.875	4.031	
3	1.329	4.347	
4	1.117	5.205	
5	1.590	5.381	
6	1.681	5.777	
7	1.381	6.541	
8	1.505	7.155	
9	1.641	7.832	
10	2.252	8.603	
11	2.360	9.872	
12	2.465	10.567	
13	2.622	11.330	
14	2.745	12.420	
15	2.876	13.604	
16	2.976	14.909	
17	3.126	16.664	
18	3.216	17.828	
19	3.271	19.072	
20	3.348	20.395	
21	3.426	21.784	
22	3.490	23.817	
23	3.549	25.466	
24	3.627	27.240	
25	3.737	29.166	
26	3.885	31.989	

	subhalo peculiar velocity x [km/s]	subhalo peculiar velocity y [km/s]	\
0	-21.856	-57.702	
1	-25.320	-59.936	
2	-33.067	-59.146	
3	-35.168	-168.075	
4	-30.115	-70.994	
5	-41.249	-193.422	
6	-45.835	-195.636	
7	-38.917	-79.613	
8	-41.672	-77.190	
9	-59.219	-86.418	
10	-63.162	-255.758	
11	-74.110	-165.371	
12	-97.686	-157.335	
13	-83.045	-228.928	
14	-103.584	-235.849	
15	-133.558	-240.763	
16	-127.281	-235.731	
17	-107.950	-220.498	
18	-102.145	-227.819	
19	-122.223	-235.654	
20	-127.539	-228.459	
21	-130.556	-222.157	
22	-129.706	-220.262	
23	-137.800	-204.404	
24	-148.658	-180.322	
25	-159.048	-165.999	
26	-194.300	-159.952	

	subhalo peculiar velocity z [km/s]	Halo mass [Msun]	Stellar mass [Msun]	\
0	-107.591	4.370600e+09	1.096800e+07	
1	-118.378	5.911400e+09	1.784500e+07	
2	-122.241	8.016200e+09	1.957100e+07	
3	-36.773	1.691900e+10	2.020900e+07	
4	-148.108	2.310800e+10	3.568900e+07	
5	-43.126	3.094600e+10	7.787400e+07	
6	-51.056	3.428200e+10	8.277200e+07	
7	-178.890	5.208700e+10	1.012500e+08	
8	-182.936	7.813400e+10	1.435300e+08	
9	-182.991	9.477300e+10	2.225500e+08	
10	-68.888	1.168200e+11	4.298200e+08	
11	-133.448	1.882900e+11	4.006300e+08	
12	-121.338	3.143700e+11	7.989200e+08	
13	-105.642	7.188600e+11	1.917900e+09	
14	-111.294	9.840200e+11	5.142900e+09	
15	-109.943	1.273600e+12	1.191500e+10	
16	-109.787	2.195900e+12	2.180900e+10	

17	-124.221	2.473700e+12	2.746700e+10
18	-127.175	2.411200e+12	2.884900e+10
19	-137.093	2.349300e+12	3.110700e+10
20	-136.367	2.502900e+12	4.264400e+10
21	-137.820	2.709300e+12	4.759300e+10
22	-137.152	2.705200e+12	5.065200e+10
23	-134.120	2.747600e+12	5.147900e+10
24	-119.502	3.005000e+12	5.222800e+10
25	-95.603	3.129000e+12	5.292200e+10
26	-73.718	3.198800e+12	5.400200e+10

	BH mass [Msun]	SFR [Msun/yr]	sSFR [/yr]
0	0.0	0.075048	6.842300e-09
1	0.0	0.004368	2.447900e-10
2	0.0	0.055810	2.851700e-09
3	734810.0	0.202340	1.001300e-08
4	734810.0	0.174820	4.898500e-09
5	734810.0	0.321770	4.131900e-09
6	734810.0	0.103300	1.248100e-09
7	734810.0	0.427730	4.224600e-09
8	734810.0	0.186170	1.297100e-09
9	1469900.0	0.280820	1.261800e-09
10	734810.0	1.197800	2.786700e-09
11	2215600.0	0.395530	9.872700e-10
12	2951600.0	1.280700	1.603000e-09
13	4464700.0	7.408200	3.862600e-09
14	5934300.0	17.772000	3.455600e-09
15	11942000.0	18.172000	1.525200e-09
16	17446000.0	19.888000	9.119000e-10
17	30772000.0	9.507300	3.461400e-10
18	31503000.0	5.116200	1.773400e-10
19	33293000.0	4.986900	1.603100e-10
20	44155000.0	6.197800	1.453400e-10
21	51633000.0	4.498700	9.452500e-11
22	63429000.0	2.709900	5.350000e-11
23	67776000.0	2.643700	5.135500e-11
24	70165000.0	2.841500	5.440600e-11
25	75923000.0	2.240600	4.233900e-11
26	78532000.0	1.710700	3.167800e-11

	index	time [Gyr]	a_exp	redshift	subhalo centre x [Mpc]	\
0	2	0.476	0.091	9.993	4.106	
1	3	0.550	0.100	8.988	4.519	
2	4	0.635	0.110	8.075	4.971	
3	5	0.760	0.124	7.050	5.589	
4	6	0.942	0.143	5.971	6.458	
5	7	1.049	0.154	5.487	6.944	
6	8	1.168	0.166	5.037	7.446	

7	9	1.348	0.182	4.485	8.185
8	10	1.556	0.201	3.984	9.040
9	11	1.795	0.221	3.528	9.913
10	12	2.144	0.249	3.017	11.137
11	13	2.653	0.287	2.478	12.812
12	14	2.949	0.309	2.237	13.739
13	15	3.276	0.332	2.012	14.718
14	16	3.767	0.365	1.737	16.134
15	17	4.325	0.402	1.487	17.696
16	18	4.958	0.443	1.259	19.416
17	19	5.864	0.499	1.004	21.815
18	20	6.472	0.536	0.865	23.387
19	21	7.131	0.576	0.736	25.052
20	22	7.841	0.619	0.615	26.844
21	23	8.603	0.665	0.503	28.765
22	24	9.698	0.732	0.366	31.531
23	25	10.577	0.787	0.271	33.769
24	26	11.501	0.846	0.183	36.177
25	27	12.469	0.909	0.101	38.773
26	28	13.821	1.000	0.000	42.533

	subhalo centre y [Mpc]	subhalo centre z [Mpc]	\
0	1.009	3.195	
1	1.096	3.515	
2	1.191	3.868	
3	1.193	4.393	
4	1.484	5.025	
5	1.475	5.420	
6	1.658	5.790	
7	1.784	6.362	
8	1.790	7.010	
9	1.988	7.667	
10	2.193	8.622	
11	2.412	9.906	
12	2.534	10.612	
13	2.653	11.376	
14	2.819	12.487	
15	2.977	13.672	
16	3.163	14.968	
17	3.389	16.770	
18	3.490	17.950	
19	3.622	19.206	
20	3.751	20.547	
21	3.866	21.993	
22	4.011	24.076	
23	4.126	25.767	
24	4.247	27.587	
25	4.360	29.530	

	subhalo peculiar velocity x [km/s]	subhalo peculiar velocity y [km/s]	\
0	-21.841	-153.131	
1	-31.803	-159.676	
2	-34.395	-170.176	
3	-29.248	-80.178	
4	-42.165	-199.801	
5	-43.590	-139.205	
6	-49.976	-206.416	
7	-53.359	-229.873	
8	-94.800	-58.193	
9	-61.912	-110.861	
10	-67.718	-186.562	
11	-80.209	-179.982	
12	-85.468	-178.255	
13	-82.616	-180.625	
14	-87.122	-185.334	
15	-85.616	-179.380	
16	-78.461	-177.481	
17	-84.698	-193.217	
18	-94.512	-199.188	
19	-97.815	-190.910	
20	-101.084	-193.278	
21	-105.616	-195.617	
22	-110.626	-198.210	
23	-112.088	-196.124	
24	-114.590	-192.905	
25	-115.478	-190.706	
26	-124.664	-183.928	

	subhalo peculiar velocity z [km/s]	Halo mass [Msun]	Stellar mass [Msun]	\
0	-16.995	4.423500e+09	9.116900e+06	
1	-28.042	8.749100e+09	1.124300e+07	
2	-26.651	1.722700e+10	2.188600e+07	
3	-49.646	9.007100e+09	1.910800e+07	
4	-36.706	3.733800e+10	1.527400e+08	
5	-129.265	4.101000e+10	6.469000e+07	
6	-53.226	8.297800e+10	3.732200e+08	
7	-55.987	1.099000e+11	5.000100e+08	
8	-172.071	1.008200e+11	2.524600e+08	
9	-108.234	3.235700e+11	6.543700e+08	
10	-89.709	8.229700e+11	2.922200e+09	
11	-90.765	1.102300e+12	1.500300e+10	
12	-83.985	1.224500e+12	2.173600e+10	
13	-79.386	1.609700e+12	2.802800e+10	
14	-88.925	2.104100e+12	3.135900e+10	
15	-101.960	2.379400e+12	3.074000e+10	

16	-106.421	2.242000e+12	3.031600e+10
17	-107.567	2.348400e+12	3.017900e+10
18	-111.896	2.524600e+12	2.992300e+10
19	-113.479	2.624600e+12	3.240800e+10
20	-112.135	2.632500e+12	3.069800e+10
21	-111.338	2.624700e+12	3.019900e+10
22	-112.638	2.771400e+12	3.002300e+10
23	-113.270	2.935100e+12	2.979200e+10
24	-111.607	3.072700e+12	2.962000e+10
25	-109.425	3.259500e+12	2.949600e+10
26	-105.335	3.470200e+12	2.943900e+10

	BH mass [Msun]	SFR [Msun/yr]	sSFR [/yr]
0	0.0	0.010837	1.188700e-09
1	0.0	0.062977	5.601200e-09
2	0.0	0.413370	1.888700e-08
3	0.0	0.072056	3.771100e-09
4	734800.0	0.817900	5.354800e-09
5	744550.0	0.126590	1.956800e-09
6	734800.0	1.415600	3.792900e-09
7	1469600.0	1.250100	2.500200e-09
8	1481300.0	0.992370	3.930800e-09
9	2967500.0	1.820700	2.782400e-09
10	5183600.0	5.020800	1.718200e-09
11	2939400.0	35.123000	2.341100e-09
12	5190800.0	32.795000	1.508800e-09
13	4431500.0	31.214000	1.113700e-09
14	82225000.0	3.013700	9.610400e-11
15	91905000.0	0.351310	1.142900e-11
16	103770000.0	1.113200	3.672000e-11
17	2250000.0	0.038565	1.277900e-12
18	740510000.0	0.005807	1.940600e-13
19	742750000.0	0.203980	6.294000e-12
20	744940000.0	0.000000	0.000000e+00
21	743470000.0	0.098116	3.249000e-12
22	743450000.0	0.000000	0.000000e+00
23	745020000.0	0.005941	1.994300e-13
24	744210000.0	0.000000	0.000000e+00
25	744960000.0	0.000000	0.000000e+00
26	744950000.0	0.000000	0.000000e+00

	index	time [Gyr]	a_exp	redshift	subhalo centre x [Mpc]	\
0	2	0.476	0.091	9.993	4.048	
1	3	0.550	0.100	8.988	4.454	
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3	5	0.760	0.124	7.050	5.521	
4	6	0.942	0.143	5.971	6.367	
5	7	1.049	0.154	5.487	6.837	

6	8	1.168	0.166	5.037	7.341
7	9	1.348	0.182	4.485	8.072
8	10	1.556	0.201	3.984	8.879
9	11	1.795	0.221	3.528	9.771
10	12	2.144	0.249	3.017	10.984
11	13	2.653	0.287	2.478	12.652
12	14	2.949	0.309	2.237	13.445
13	15	3.276	0.332	2.012	14.558
14	16	3.767	0.365	1.737	15.973
15	17	4.325	0.402	1.487	17.526
16	18	4.958	0.443	1.259	19.213
17	19	5.864	0.499	1.004	21.506
18	20	6.472	0.536	0.865	23.024
19	21	7.131	0.576	0.736	24.669
20	22	7.841	0.619	0.615	26.452
21	23	8.603	0.665	0.503	28.296
22	24	9.698	0.732	0.366	31.093
23	25	10.577	0.787	0.271	33.251
24	26	11.501	0.846	0.183	35.483
25	27	12.469	0.909	0.101	37.864
26	28	13.821	1.000	0.000	41.269

	subhalo centre y [Mpc]	subhalo centre z [Mpc]	\
0	0.721	3.349	
1	0.788	3.678	
2	0.861	4.038	
3	0.960	4.536	
4	1.093	5.214	
5	1.164	5.588	
6	1.239	5.986	
7	1.343	6.560	
8	1.454	7.179	
9	1.577	7.853	
10	1.726	8.788	
11	1.925	10.038	
12	2.115	10.466	
13	2.129	11.454	
14	2.266	12.488	
15	2.405	13.599	
16	2.551	14.801	
17	2.689	16.516	
18	2.753	17.662	
19	2.811	18.906	
20	2.871	20.223	
21	2.945	21.607	
22	2.978	23.618	
23	2.978	25.212	
24	3.105	27.022	

25	3.200	29.013
26	3.307	31.937

	subhalo peculiar velocity x [km/s]	subhalo peculiar velocity y [km/s]	\
0	-19.110	-69.700	
1	-20.794	-73.017	
2	-31.164	-76.802	
3	-30.483	-81.084	
4	-36.396	-86.085	
5	-33.036	-90.824	
6	-33.911	-100.549	
7	-36.496	-107.515	
8	-42.890	-111.491	
9	-53.968	-118.613	
10	-61.144	-126.428	
11	-73.054	-133.473	
12	-46.727	-182.261	
13	-86.770	-144.383	
14	-95.505	-150.348	
15	-106.666	-154.860	
16	-141.246	-167.613	
17	-143.119	-202.725	
18	-144.976	-199.824	
19	-124.567	-198.770	
20	-119.220	-217.191	
21	-108.894	-199.071	
22	-151.289	-189.430	
23	-199.305	-167.196	
24	-224.969	-146.344	
25	-258.649	-144.478	
26	-312.245	-142.591	

	subhalo peculiar velocity z [km/s]	Halo mass [Msun]	Stellar mass [Msun]	\
0	-102.127	4.279900e+09	9.563200e+06	
1	-109.488	5.773000e+09	1.258000e+07	
2	-116.676	7.186900e+09	1.452000e+07	
3	-125.396	1.086000e+10	1.835600e+07	
4	-132.398	1.968800e+10	3.718900e+07	
5	-143.268	2.704600e+10	6.172900e+07	
6	-159.781	3.564800e+10	6.895900e+07	
7	-172.125	4.934100e+10	9.424500e+07	
8	-173.232	6.335000e+10	1.521500e+08	
9	-172.025	8.940700e+10	2.240400e+08	
10	-183.027	9.500300e+10	3.535800e+08	
11	-196.441	1.201600e+11	5.568900e+08	
12	-64.857	1.412600e+11	2.364200e+08	
13	-213.452	1.507900e+11	7.984600e+08	
14	-230.821	1.711900e+11	1.080400e+09	

15	-243.080	2.019400e+11	1.469900e+09
16	-215.061	5.433300e+11	1.951900e+09
17	-168.319	5.065400e+11	3.181900e+09
18	-159.933	8.107500e+11	4.687700e+09
19	-136.450	1.190200e+12	6.127700e+09
20	-135.156	1.865000e+12	7.730800e+09
21	-134.723	1.911600e+12	1.071300e+10
22	-139.743	3.587500e+12	1.314900e+10
23	-111.574	3.291100e+12	2.341300e+10
24	-76.200	3.403400e+12	3.148900e+10
25	-35.888	3.067300e+12	3.445500e+10
26	0.642	2.905200e+12	3.979200e+10

	BH mass [Msun]	SFR [Msun/yr]	sSFR [/yr]
0	0.0	0.070834	7.406900e-09
1	0.0	0.032182	2.558200e-09
2	0.0	0.141120	9.718800e-09
3	0.0	0.018007	9.810100e-10
4	734800.0	0.282010	7.583100e-09
5	734800.0	0.059260	9.600000e-10
6	734800.0	0.375210	5.441000e-09
7	734800.0	0.257000	2.726900e-09
8	734800.0	0.307550	2.021400e-09
9	734800.0	0.306450	1.367800e-09
10	1469600.0	0.877290	2.481200e-09
11	1469600.0	0.397820	7.143700e-10
12	1475900.0	0.533400	2.256200e-09
13	1469600.0	0.489030	6.124600e-10
14	1469600.0	1.043300	9.657000e-10
15	1469600.0	0.973250	6.621000e-10
16	1469600.0	1.779200	9.115400e-10
17	2939200.0	2.398200	7.537000e-10
18	2204400.0	3.584500	7.646500e-10
19	2204400.0	3.051000	4.979000e-10
20	2204400.0	4.292600	5.552700e-10
21	2956000.0	5.280000	4.928400e-10
22	734800.0	5.184700	3.943000e-10
23	5923100.0	16.126000	6.887700e-10
24	14069000.0	5.107400	1.622000e-10
25	22935000.0	4.034400	1.170900e-10
26	32110000.0	3.827400	9.618400e-11

```
[2]: fig, ax1 = plt.subplots()
fig.set_size_inches(15,10)

colour = 'tab:red'
```

```

ax1.yaxis.set_tick_params(which='major', size=5, width=1, direction='in',
    ↪right='on')

df_o.plot(ax=ax1, x=1, y=10, color=colour, legend=None)
ax1.tick_params(axis='y', labelcolor=colour)
ax1.yaxis.offsetText.set_visible(False)
ax1.set_xlabel('Time (Gyr)')
ax1.set_ylabel('Halo mass (Msun) x 1012', color=colour)

ax2 = ax1.twinx()
ax2_range = np.arange(1e7, 6e10, 1e7)
colour = 'tab:blue'
ax2.yaxis.set_tick_params(which='major', size=5, width=1, direction='in',
    ↪right='on')

ax2.yaxis.offsetText.set_visible(False)

ax2.set_ylabel('Stellar Mass (Msun) x 1010', color=colour)

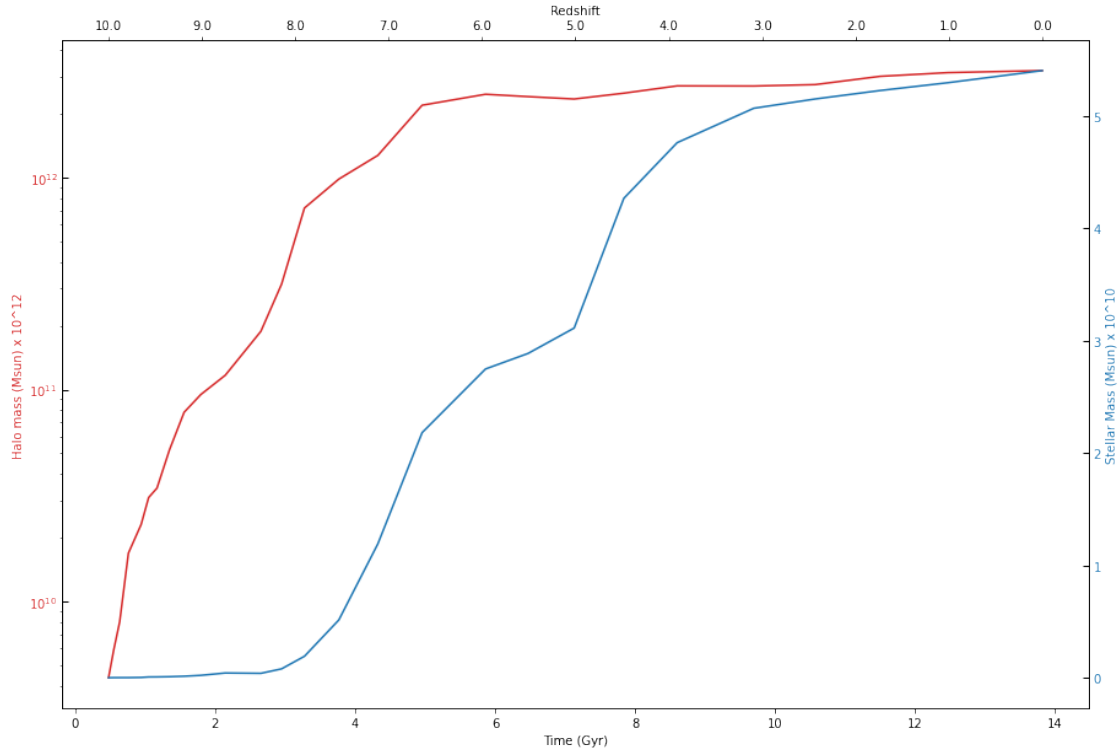
#

ax4 = ax1.twinx()
xticks = np.arange(min(df_o["redshift"])- 1, max(df_o["redshift"])+1.5, 1)
ax4.set_xticks(xticks)
ax4.set_xticklabels(xticks[::-1])
ax4.set_xlabel('Redshift')
plt.xlim(-0.5, 10.5)

df_o.plot(ax=ax2, x=1, y=11, color=colour, legend=None)
ax2.tick_params(axis='y', labelcolor=colour)

plt.semilogy()
plt.show()

```



```
[3]: fig, ax1 = plt.subplots()
fig.set_size_inches(15,10)

colour = 'tab:red'

ax1.yaxis.set_tick_params(which='major', size=5, width=1, direction='in',
    ↪right='on')

df_o.plot(ax=ax1, x=1, y=10, color=colour, legend=None)
ax1.tick_params(axis='y', labelcolor=colour)
ax1.yaxis.offsetText.set_visible(False)
ax1.set_xlabel('Time (Gyr)')
ax1.set_ylabel('Halo mass (Msun) x 10^12', color=colour)

ax2 = ax1.twinx()
ax2_range = np.arange(1e7, 6e10, 1e7)
colour = 'tab:blue'
ax2.yaxis.set_tick_params(which='major', size=5, width=1, direction='in',
    ↪right='on')

ax2.yaxis.offsetText.set_visible(False)
```

```

ax2.set_ylabel('BH Mass (Msun) x 107', color=colour)

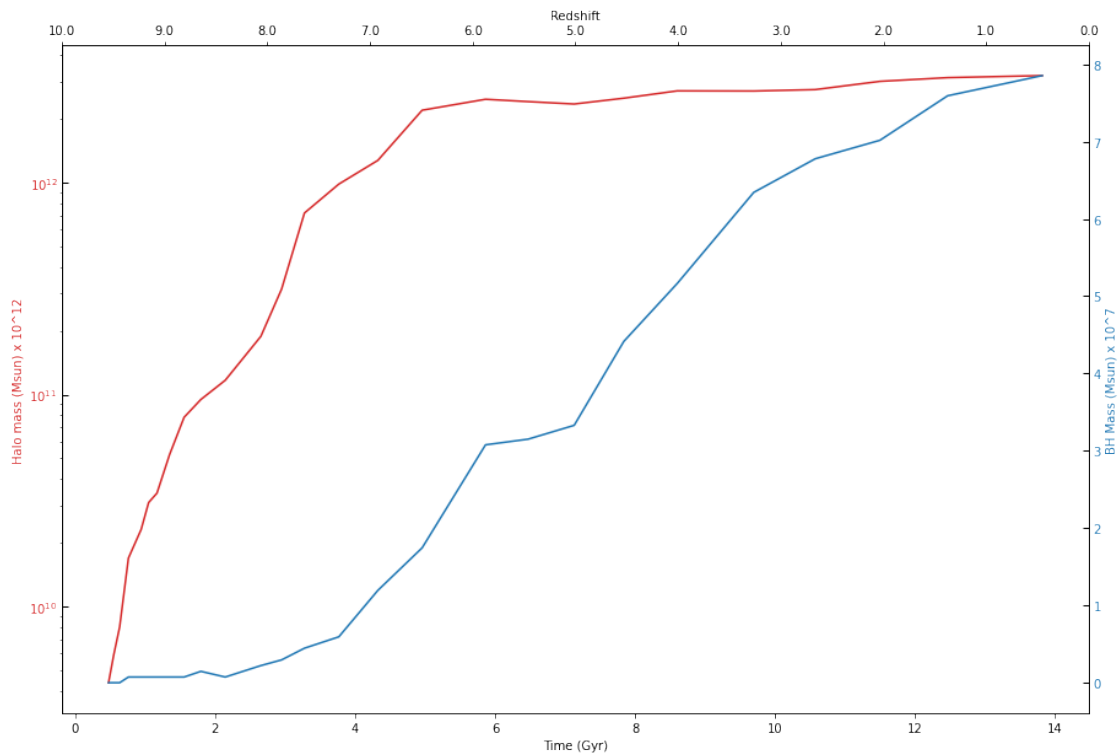
#

ax4 = ax1.twin()
xticks = np.arange(min(df_o["redshift"])-0, max(df_o["redshift"])+1, 1)
ax4.set_xticks(xticks)
ax4.set_xticklabels(xticks[::-1])
ax4.set_xlabel('Redshift')

df_o.plot(ax=ax2, x=1, y=12, color=colour, legend=None)
ax2.tick_params(axis='y', labelcolor=colour)

plt.semilogy()
plt.show()

```



```

[4]: fig, ax1 = plt.subplots()
fig.set_size_inches(15,10)

colour = 'tab:red'

ax1.yaxis.set_tick_params(which='major', size=5, width=1, direction='in',
    ↪right='on')

```

```

df_o.plot(ax=ax1, x=1, y=11, color=colour, legend=None)
ax1.tick_params(axis='y', labelcolor=colour)

ax1.set_xlabel('Time (Gyr)')
ax1.set_ylabel('Stellar mass (Msun)', color=colour)

ax2 = ax1.twinx()
ax2_range = np.arange(1e7, 6e10, 1e7)
colour = 'tab:blue'

ax2.yaxis.set_tick_params(which='major', size=5, width=1, direction='in',
    ↪right='on')

ax2.set_ylabel('Star Formation Rate (Msun/yr)', color=colour)

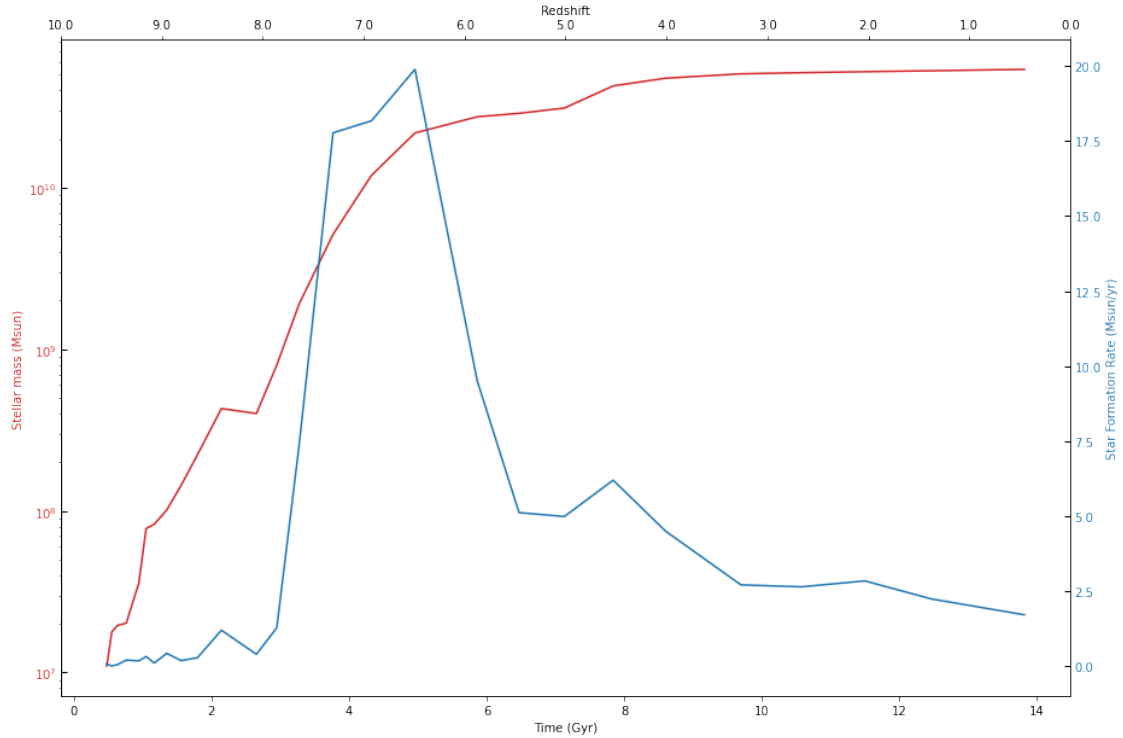
#

ax4 = ax1.twinx()
xticks = np.arange(min(df_o["redshift"])-0, max(df_o["redshift"])+1, 1)
ax4.set_xticks(xticks)
ax4.set_xticklabels(xticks[::-1])
ax4.set_xlabel('Redshift')

df_o.plot(ax=ax2, x=1, y=13, color=colour, legend=None)
ax2.tick_params(axis='y', labelcolor=colour)

plt.semilogy()
plt.show()

```



[5]: *# Stellar mass vs. time for the three galaxzies*

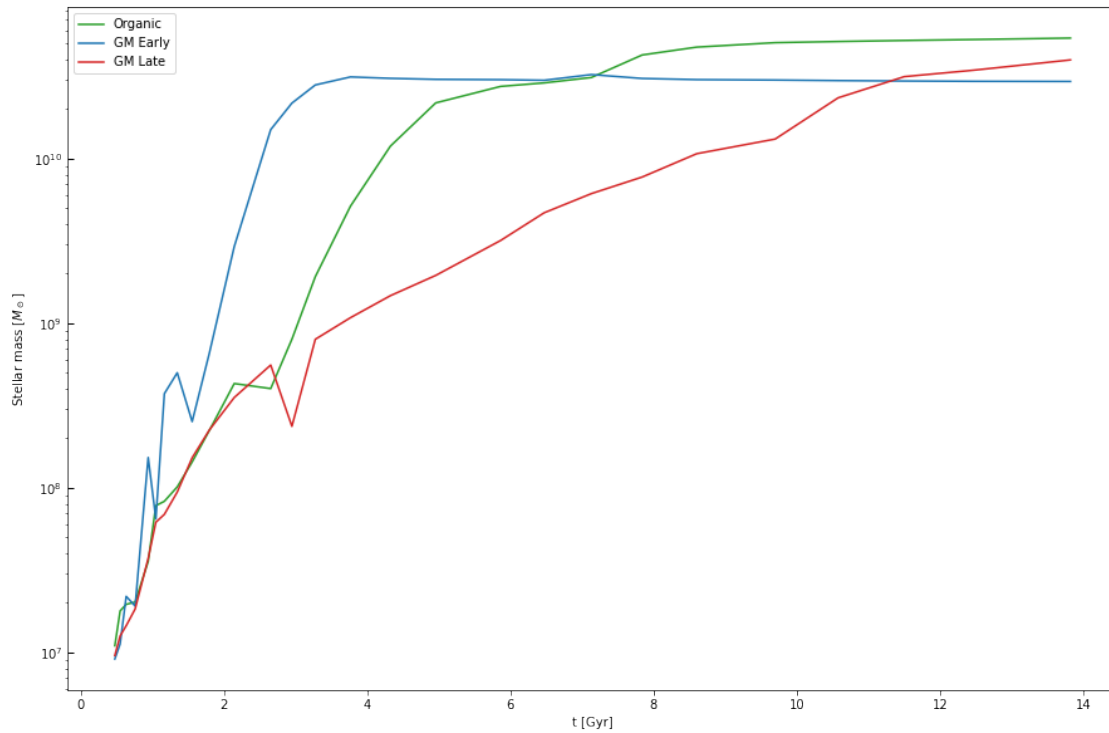
```
fig, ax1 = plt.subplots()
fig.set_size_inches(15,10)

ax1.yaxis.set_tick_params(which='major', size=5, width=1, direction='in')

df_o.plot(ax=ax1, x=1, y=11, color='tab:green', label='Organic')
df_e.plot(ax=ax1, x=1, y=11, color='tab:blue', label='GM Early')
df_l.plot(ax=ax1, x=1, y=11, color='tab:red', label='GM Late')

ax1.set_xlabel('t [Gyr]')
ax1.set_ylabel('Stellar mass [$M_{\odot}$]')

plt.rcParams['font.size'] = '24'
plt.rcParams['font.family'] = 'STIXGeneral'
plt.semilogy()
plt.show()
```



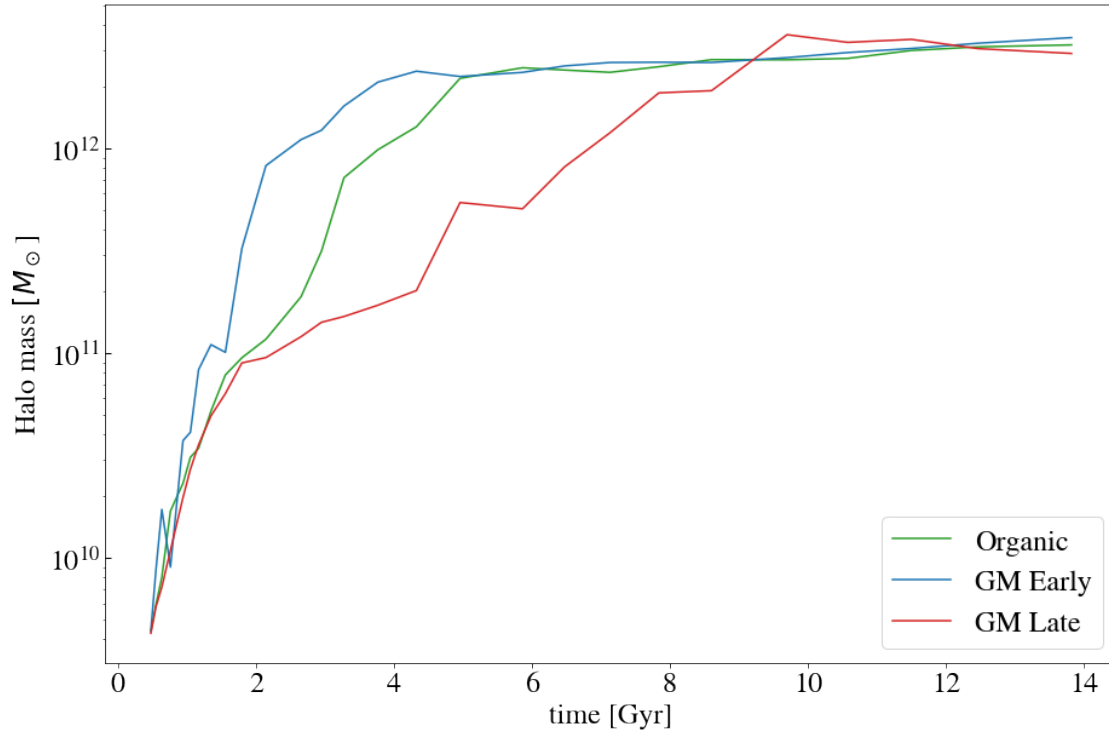
```
[6]: # halo mass vs cosmic time for the three galaxies

fig, ax1 = plt.subplots()
fig.set_size_inches(15,10)

ax1.yaxis.set_tick_params(which='major', size=5, width=1, direction='in',
    ↪right='on')
ax1.tick_params(axis='y')
ax1.set_xlabel('t [Gyr]')
ax1.set_ylabel('Halo mass  $[M_{\odot}]$ ')

df_o.plot(ax=ax1, x=1, y=10, color='tab:green', label='Organic')
df_e.plot(ax=ax1, x=1, y=10, color='tab:blue', label='GM Early')
df_l.plot(ax=ax1, x=1, y=10, color='tab:red', label='GM Late')

plt.semilogy()
plt.show()
```

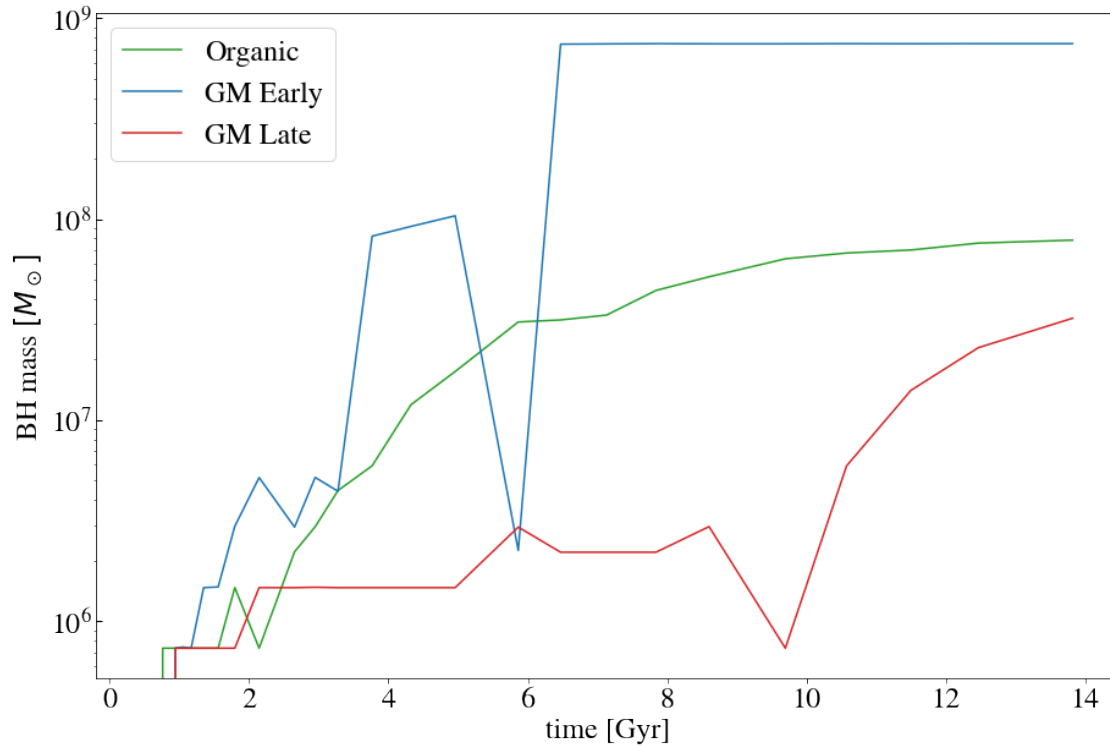
```
[7]: # BH mass vs cosmic time for the three galaxies

fig, ax1 = plt.subplots()
fig.set_size_inches(15,10)

ax1.yaxis.set_tick_params(which='major', size=5, width=1, direction='in',
    ↪right='on')
ax1.tick_params(axis='y')
ax1.set_xlabel('t [Gyr]')
ax1.set_ylabel('BH mass  $[M_{\odot}]$ ')

df_o.plot(ax=ax1, x=1, y=12, color='tab:green', label='Organic')
df_e.plot(ax=ax1, x=1, y=12, color='tab:blue', label='GM Early')
df_l.plot(ax=ax1, x=1, y=12, color='tab:red', label='GM Late')

plt.semilogy()
plt.show()
```



```
[8]: # Star formation rate vs cosmic time for the three galaxies

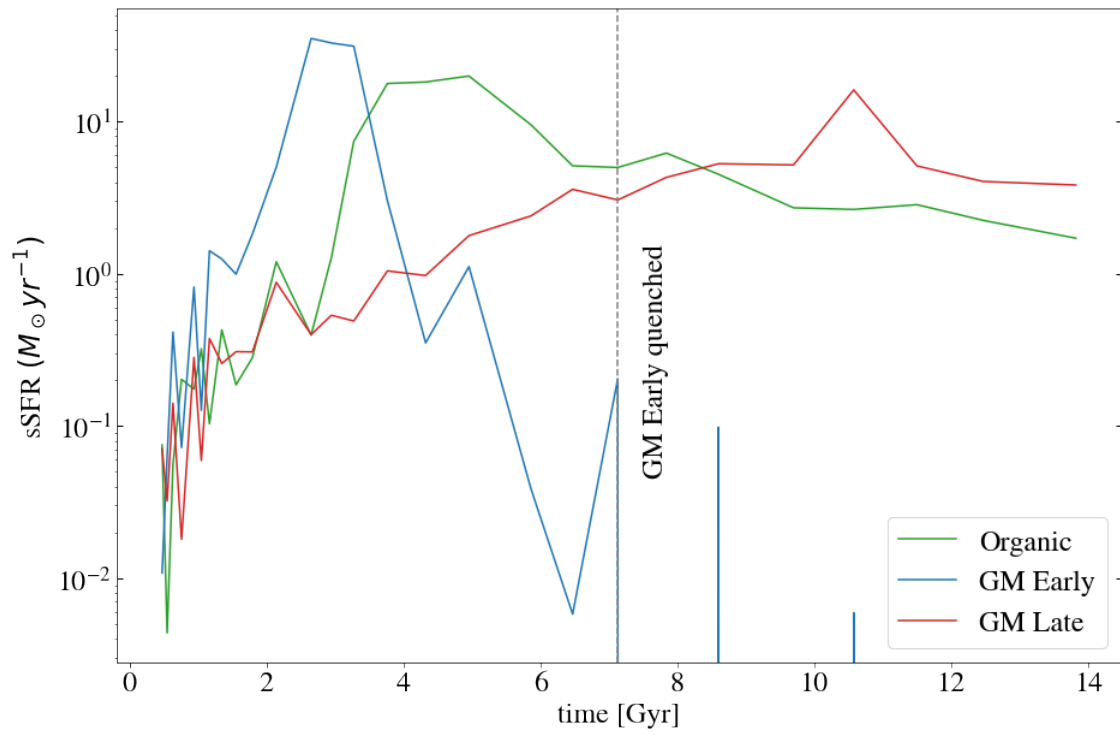
fig, ax1 = plt.subplots()
fig.set_size_inches(15,10)

ax1.yaxis.set_tick_params(which='major', size=5, width=1, direction='in',
    ↪right='on')
ax1.tick_params(axis='y')
ax1.set_xlabel('t [Gyr]')
ax1.set_ylabel('sSFR  $\{M_{\odot}\text{yr}^{-1}\}$ ')

df_o.plot(ax=ax1, x=1, y=13, color='tab:green', label='Organic')
df_e.plot(ax=ax1, x=1, y=13, color='tab:blue', label='GM Early')
df_l.plot(ax=ax1, x=1, y=13, color='tab:red', label='GM Late')

plt.axvline(x=7.13, color='grey', linestyle='dashed')
plt.text(7.5,0.05,'GM Early quenched',rotation=90)

plt.semilogy()
plt.show()
```



[]: