Monday, 11 March 2019

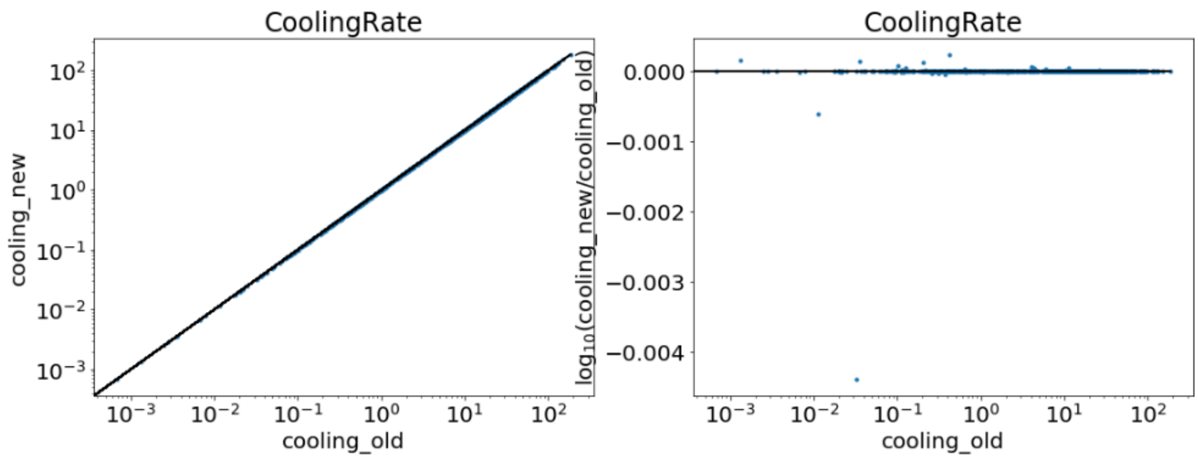
Cooling

Tidying up of model_cooling

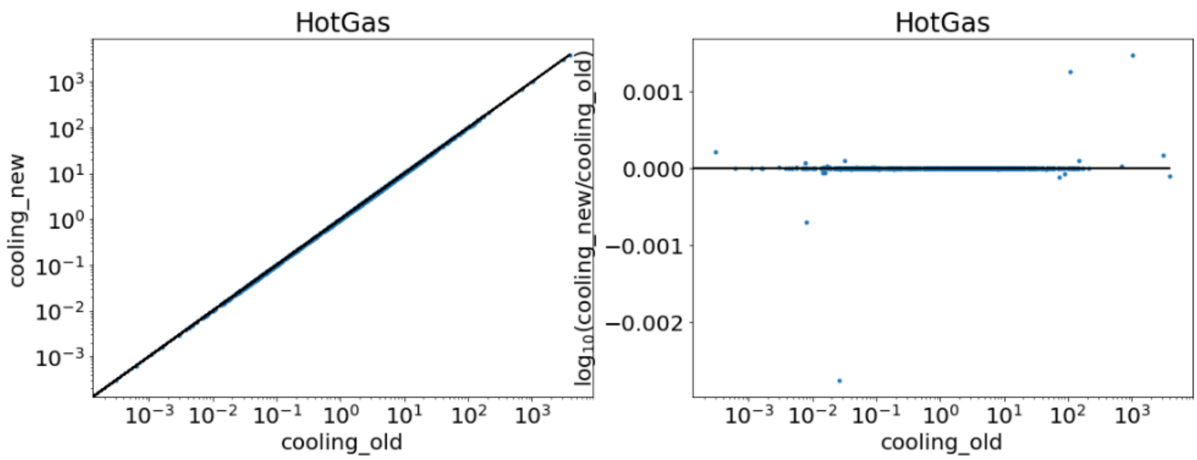
I have tidied up model_cooling so that, as far as I can tell, it does the same as previously. The new routine is called model_cooling_new.c and the old one has been renamed to model_cooling_old.c.

Unfortunately, the number of output galaxies produced is not **exactly** the same, although it is very similar. If we restrict to those galaxies in common, then this is what we get:

Amount of gas cooled:



Hot gas in halo:



– that’s good enough for me.

model_cooling.c is a logical link to model_cooling_new.c

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New cooling routine

Is as described in Paper_cooling draft.

The basic idea is that we model the HotGas atmosphere as a beta=2/3 model. Then the cooling rate can be calculated, and an isothermal cooling flow model assumed to determine the amount of cooled gas.

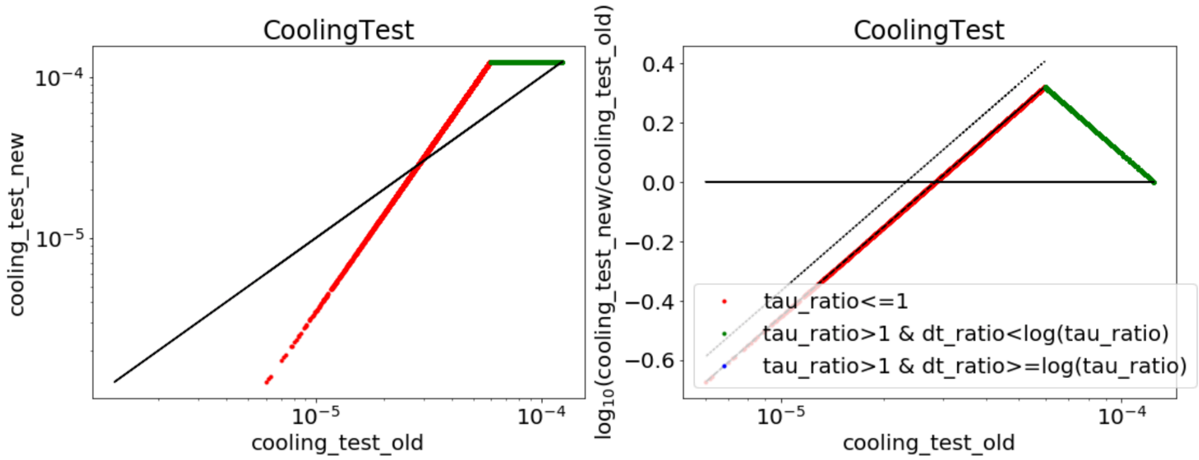
Testing

Is tricky. The paper does idealised tests of the concept, but we want to make sure that we have implemented it properly in L-Galaxies. The only way that I can think to do it is to force idealised properties for all halos. So the following sets T=Tvir, hotMass=f_fac*BaryonFrac*Mvir, tot_metals=Z*hotMass, dt=t_fac*dt.

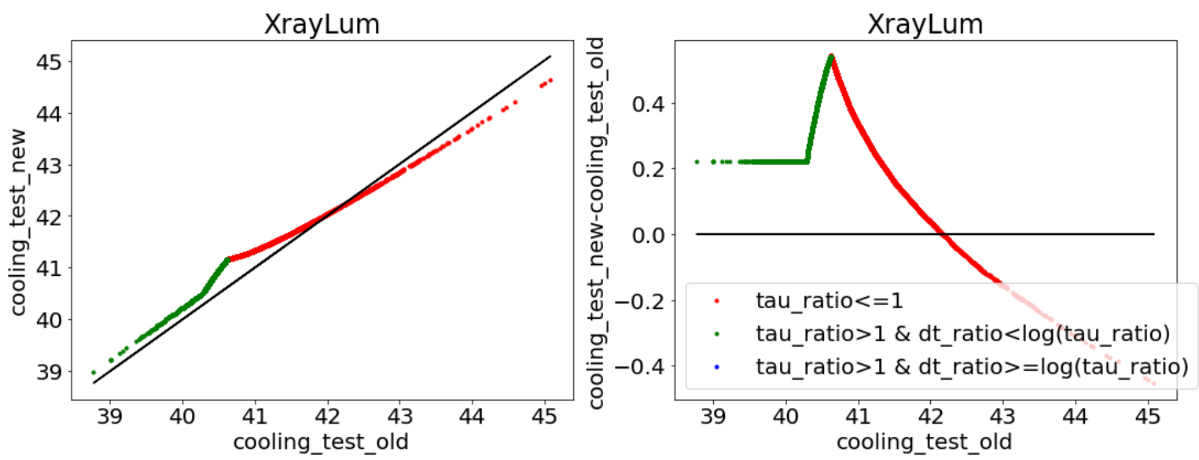
(0) f_fac=1, Z=0., dt=0.01*dt

A regime in which there is likely to be little cooling

This first plot shows the ratio of the fraction of gas cooled in each case



and this shows the ratio of the calculated X-ray luminosity



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Notes:

- Where tau_ratio>1 then we have a constant fraction of gas cooled in the new regime. This is where the cooling time of the halo is less than the dynamical time. The model then restricts the amount of gas that can cool to the amount that can flow inwards in a dynamical time, so this is correct.
- dt_ratio is the same (and very small) for all these halos, so the line sloping down to the left follows the increase in cooling time / reduction in tau_ratio. The dotted line shows the expected ratio of the two cooling methods; the dashed line (ie the one that fits well) shows the ratio after correcting the original code for a missing Hubble_h factor.
- In the case of small mass deposition, the ratio of the X-ray luminosities should be new/old=2.5/1.5=5/3≈1.67, which it is: log10(1.67)≈0.22.
- Both methods estimate X-ray luminosity from the amount of energy emitted by cooling gas, so the ratio simply depends upon the ratio of cooled gas.

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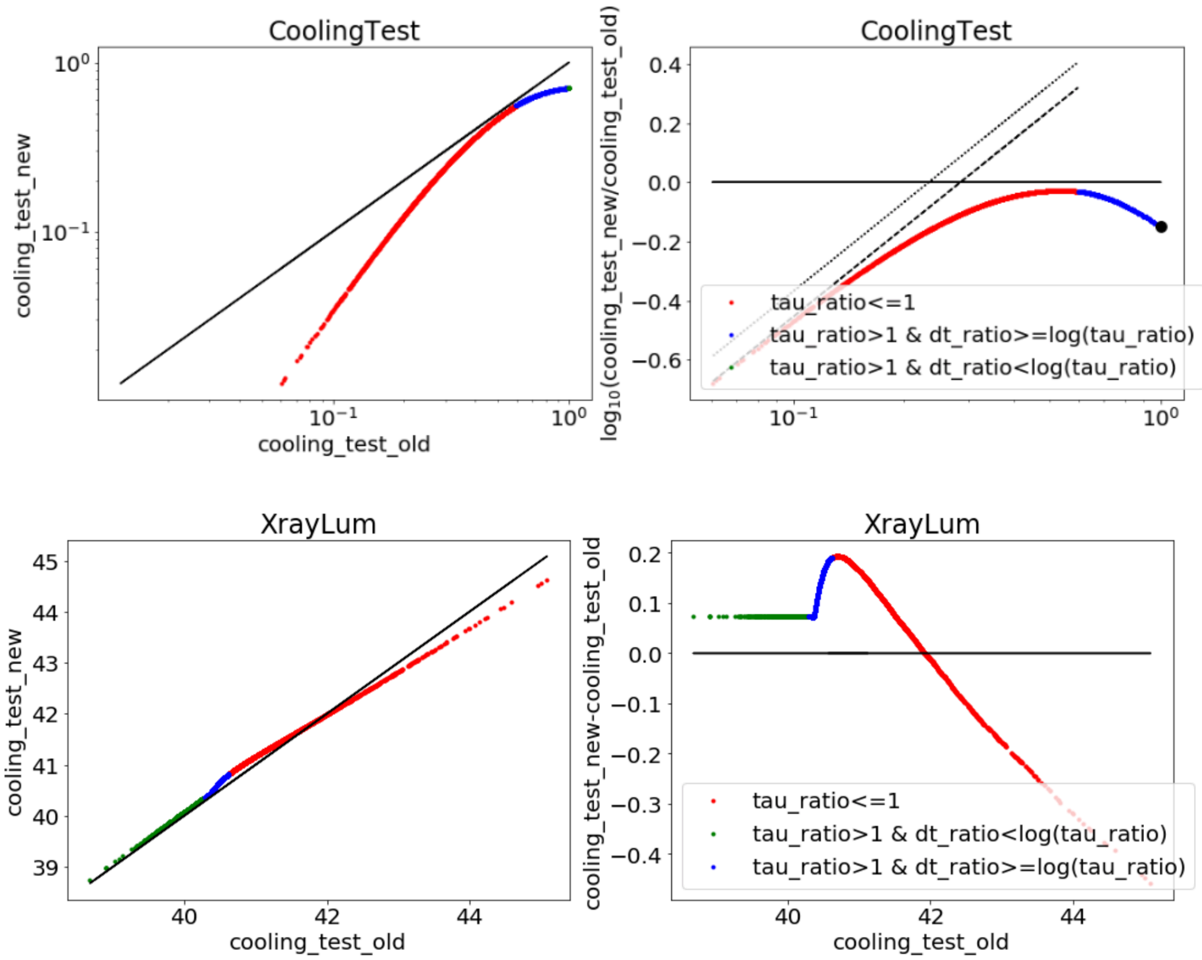
(1) f_fac=1, Z=0., dt=100*dt (ie cool for long time)



Notes:

- In this regime, dt_ratio is (just) bigger than unity (but less than unity for the original model). The very right-hand tip of cooled fraction curve corresponds to small dt_ratios. In this regime we expect the ratio of cooling times to correspond to the marked dot.

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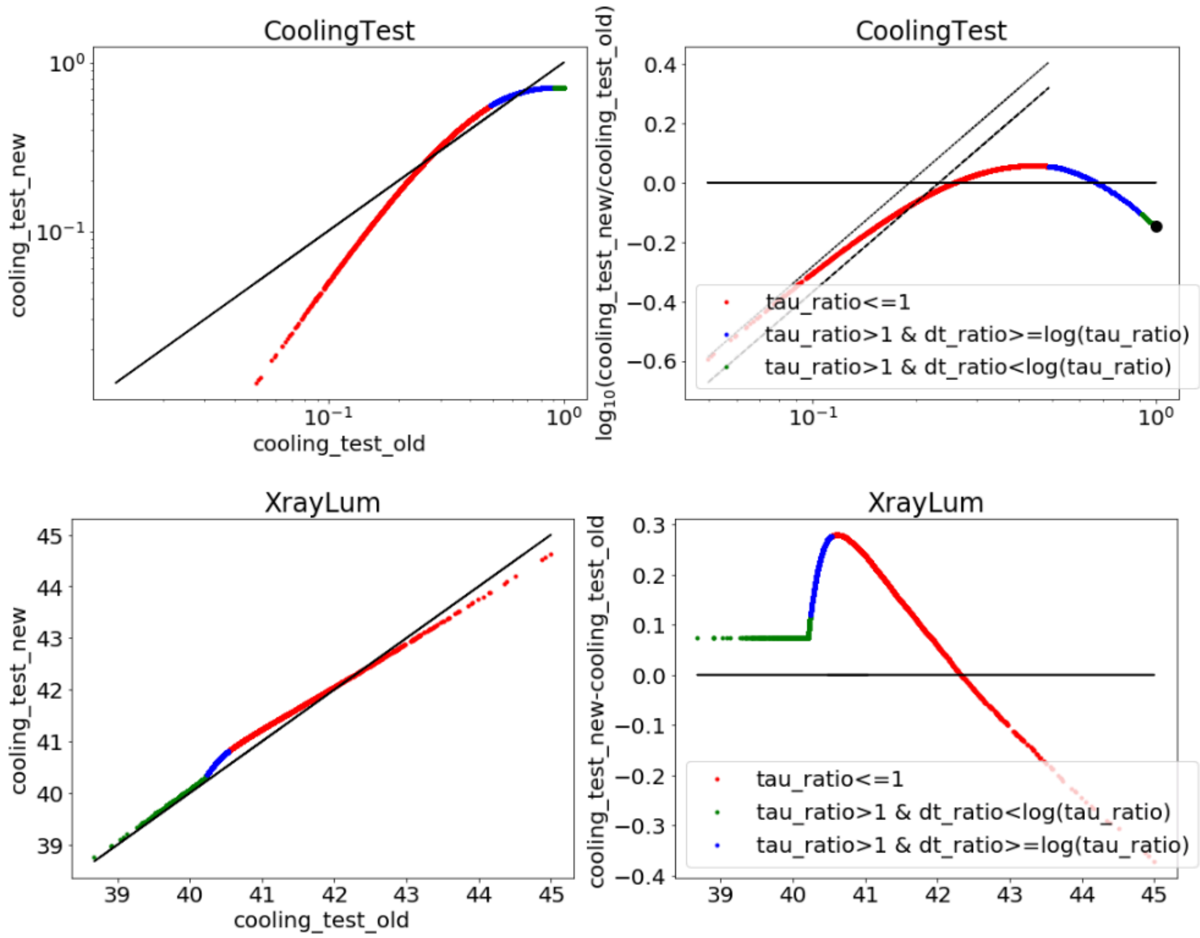
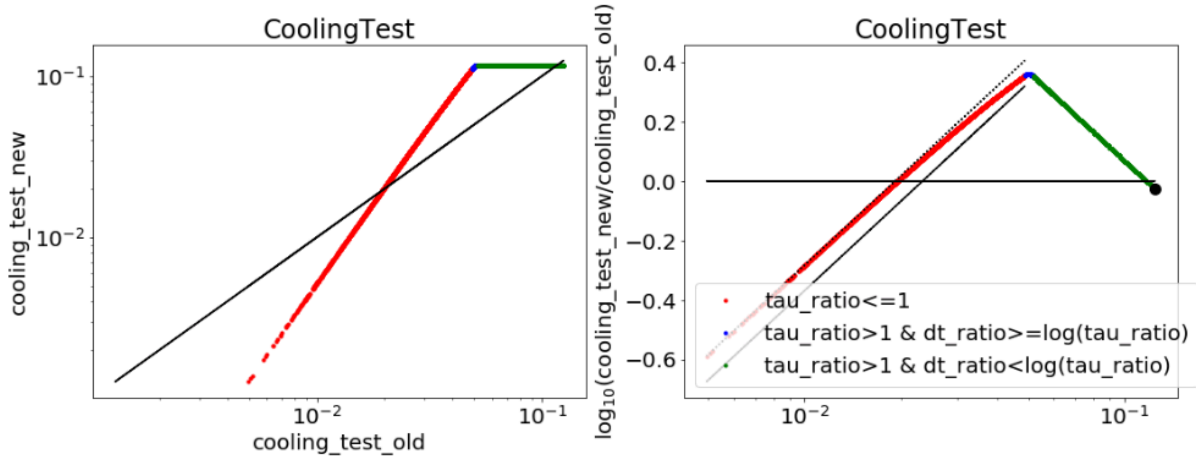
(2) As for (1) but with missing h added to cooling_old



Notes:

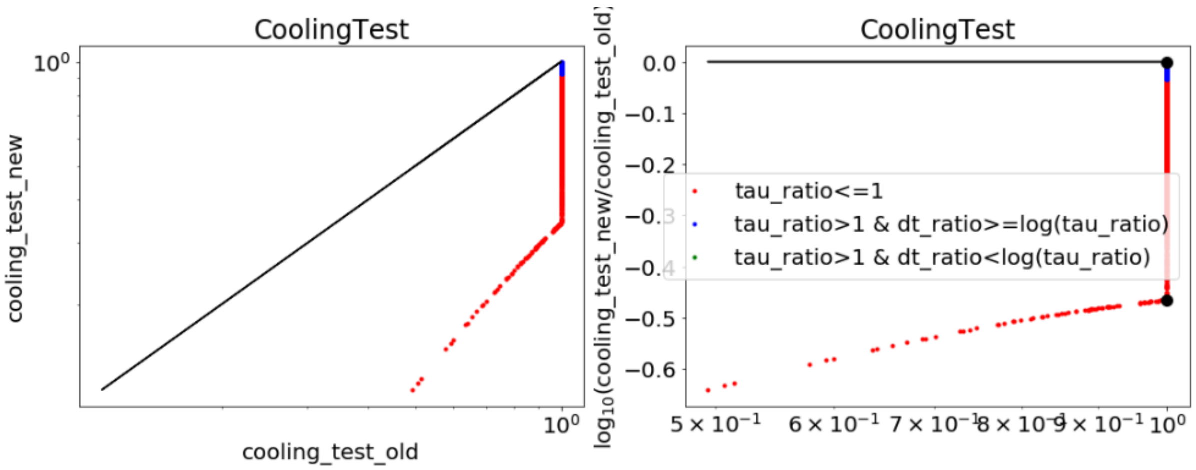
- The two cooled fractions now match correctly onto the expectations for small cooled fractions.

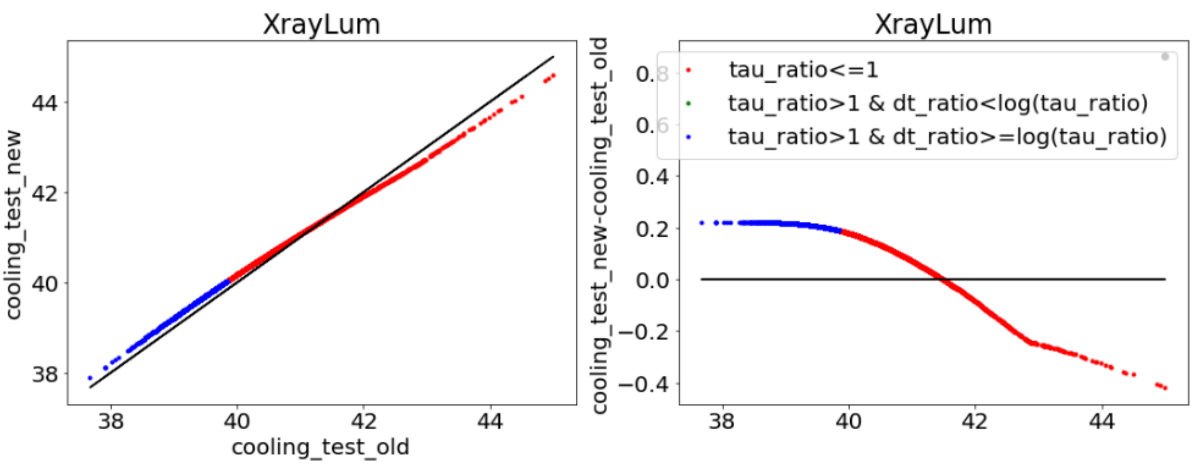
(3) f_fac=1, Z=0, dt=10*dt, missing h added to cooling_old



Note: to show that works in this regime also. Again the black dot is the theoretical ratio, this time for a cooled fraction less than unity.

(4) f_fac=1, Z=0., dt=1000*dt, missing h added to cooling_old

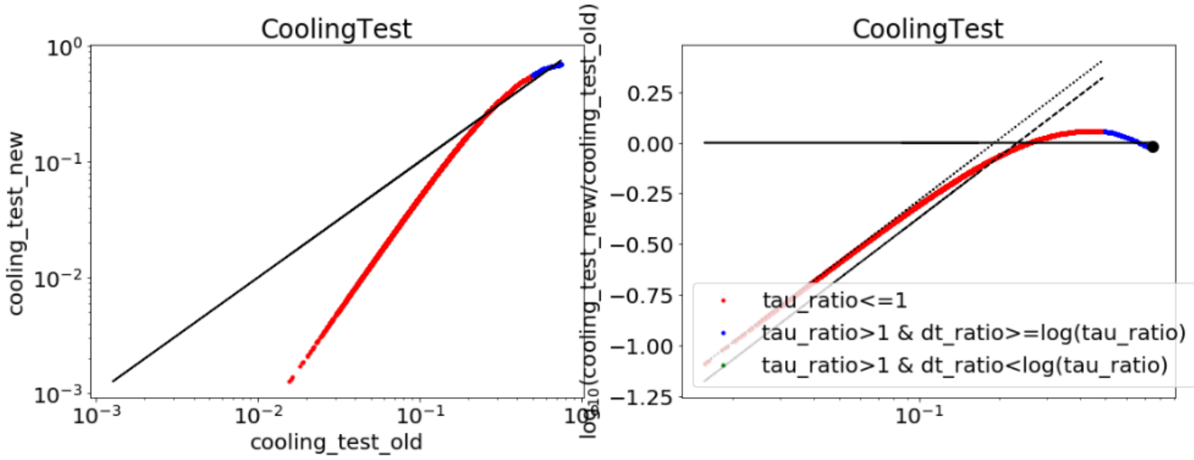




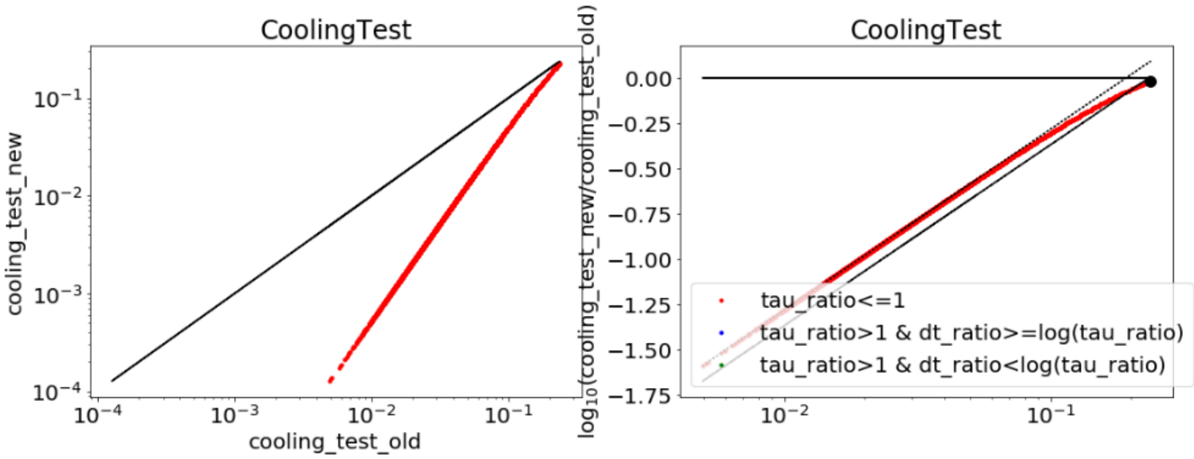
Notes:

- Both cooling fractions should saturate at 1 and they do.
- The ratio of the gas cooled when the old method saturates to unity is shown by the location of the lower black dot in the cooling test plot and is exactly correct.

(5) f_fac=0.1, Z=0, dt=100*dt, missing h added — ie cooling time mostly now longer than dynamical time



(6) f_fac=0.01, Z=0, dt=100*dt, missing h added — ie cooling time everywhere longer than dynamical time



(7) f_fac=0.01, Z=0.02, dt=100*dt, missing h added — to test the introduction of extra cooling from metallicity