BCG Mass Evolution in Cosmological Hydro-Simulations

(a work in conclusion)

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Plan:

- Describe this work in some details
- Perhaps advertise/quickly summarize another one (Gjergo+)

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Motivations

- BCGs at some point become special, by definition
- Possible mechanisms of late growth (say $z < 1$) related to special position are cooling flows (Cowie & Binney 1977; Fabian & Nelson 1977) and galactic cannibalism (Ostriker & Temaine 1975; White 1976)
- Important cooling flows are lacking at low z, which is among the main reasons why AGN feedback was introduced in any kind of model (Granato+2004; Bower+2007; Sijacki+2007)
- Most models ascribe now the late growth to (minor dry) mergers, but could produce larger mass growth wrt observational estimates done in the last decade

Motivations

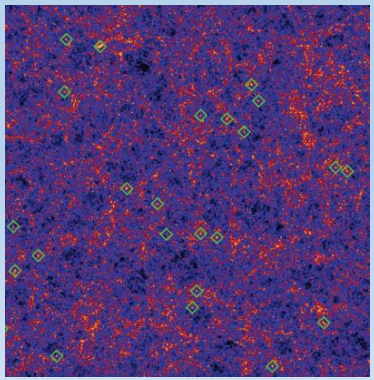
Possible theoretical techniques to model BCGs growth:

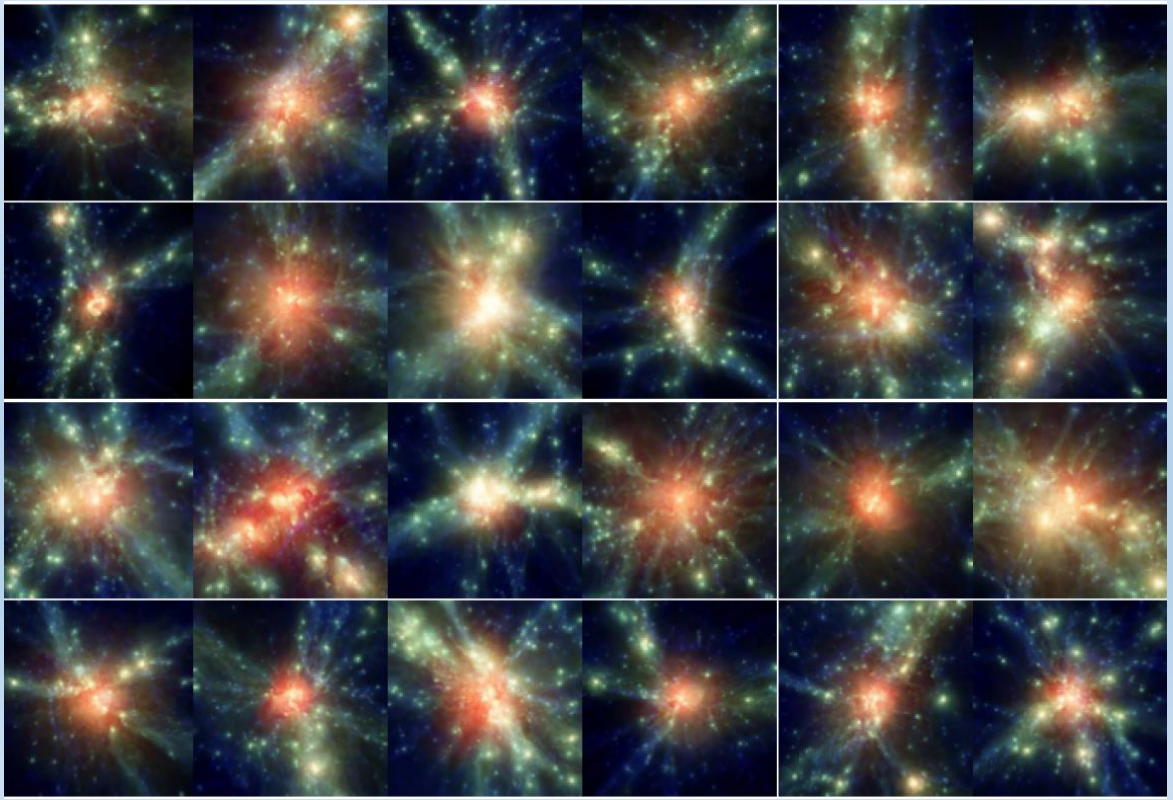
- SemiAnalyticModels (e.g. Aragon-Salamanca+1998; De Lucia & Blaizot 2007): limitations are that BCG peculiarity is imposed by construction and lack of spatial information;
- Gravity only simulations in which (sub)halos are at some point ($z \approx 2$) populated with phenomenological N-body stellar systems (e.g. Dubinsky 1998; Ruszkowski & Springel 2009): limitation is that gas processes are totally neglected, clearly an oversimplification;
- Cosmological hydro-dynamical simulations. No study so far specifically devoted to BCGs growth (TTBOMK). Let's do it.

OUR "TRIESTE" SIMULATIONS

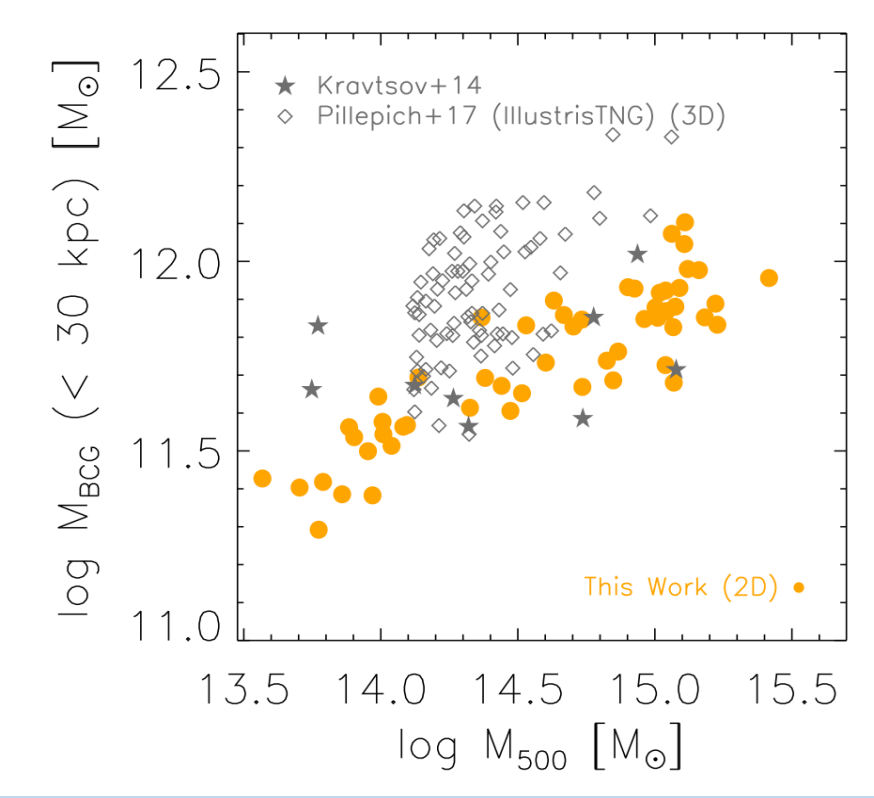
DIANOGA SET: 24 most massive clusters + 5 "random" smaller clusters (M_{200} > 1e15 and M_{200} = a few 1e14 h^{-1} $M_{\odot}$ at z=0 resp.) identified in a parent gravity only sims, box 1 Gpc h^{-1}, re-simulated at much higher resolution in boxes of about 60 Mpc, including hydro and typical sub-resolution baryonic physics. These boxes contain many other smaller mass clusters, used in some analyses.

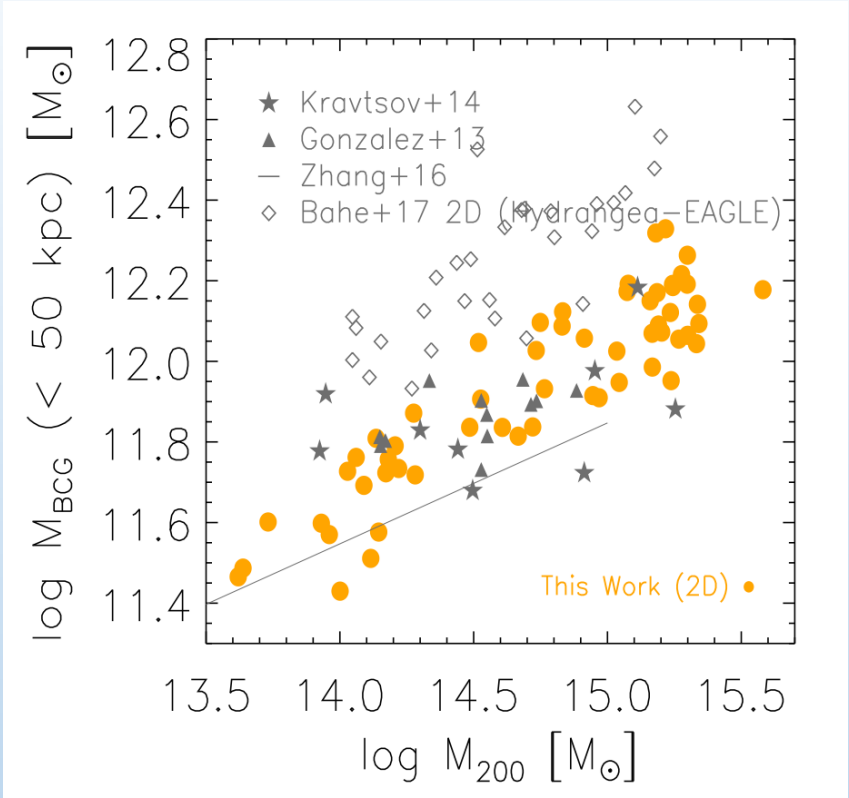
Cooling, star formation, stellar feedback (energetic and chemical), SMBH growth, AGN feedback





Final stellar mass of BCGs vs cluster mass

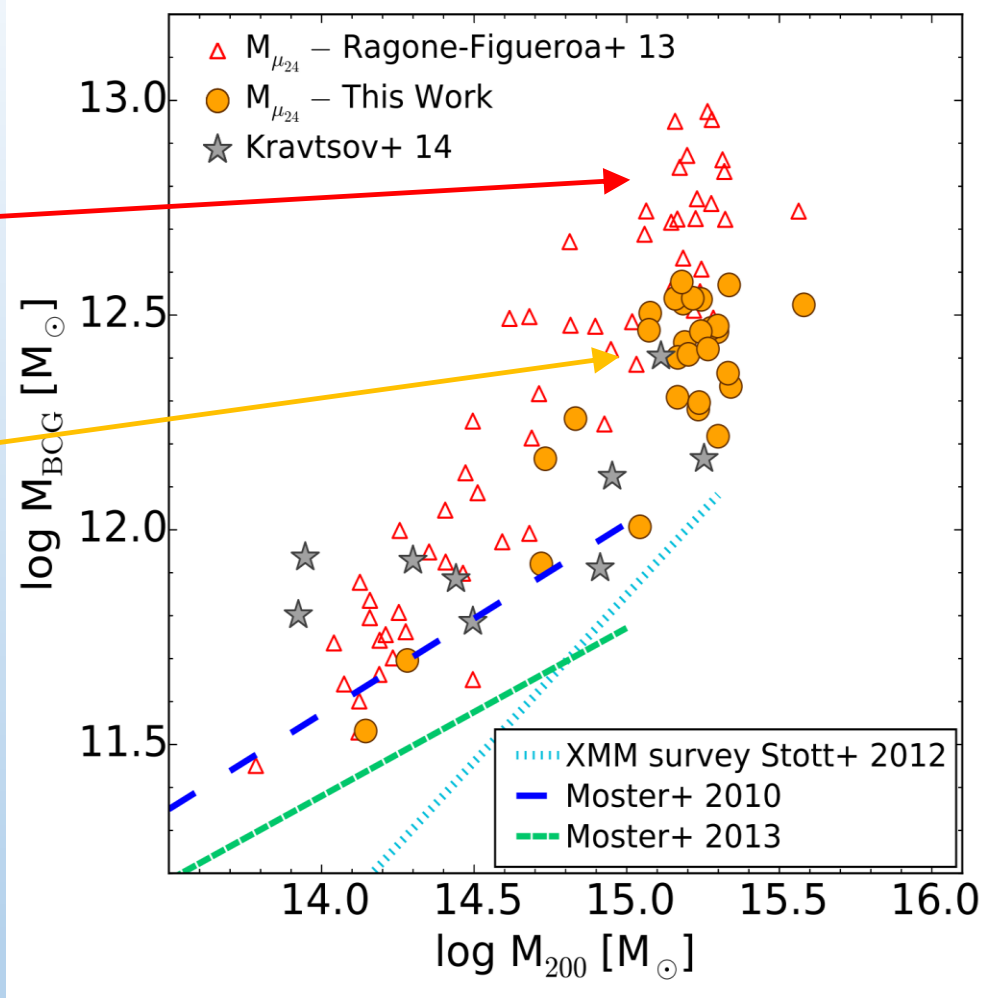




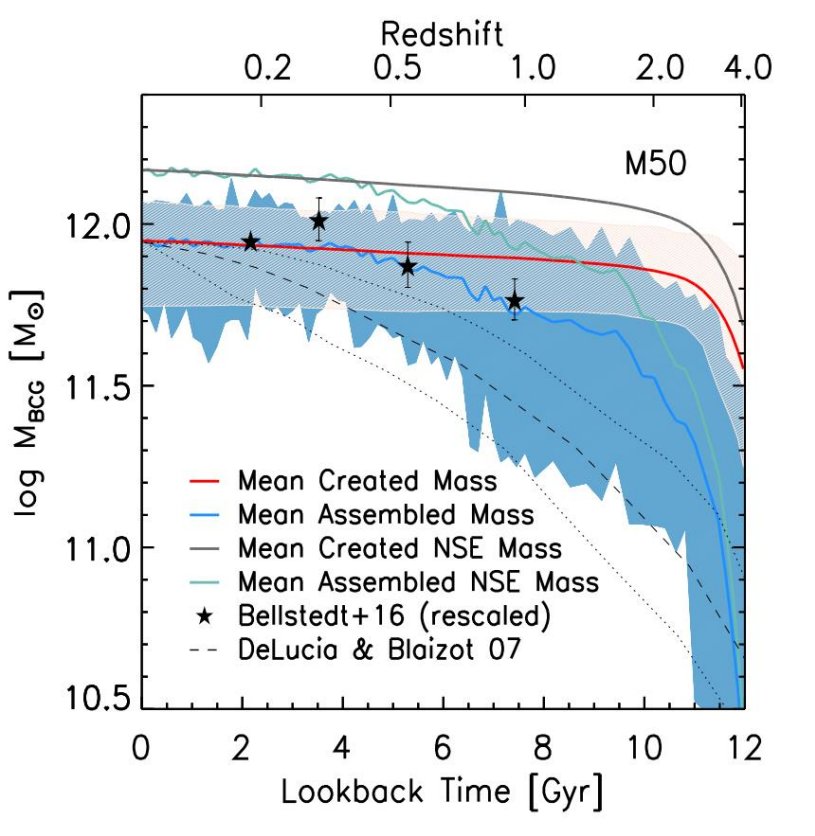
- BCG total mass ill defined. Cleanest way out: use M within given R.
- Our BCG masses smaller than other state of the art cluster simulations (Hydrangea-EAGLE and Illustris).
- As such, more in keeping with data
- Quite stable by increasing mass resolution up to 10x
  - Also smaller than previous version of our simulations (Ragone+2013).

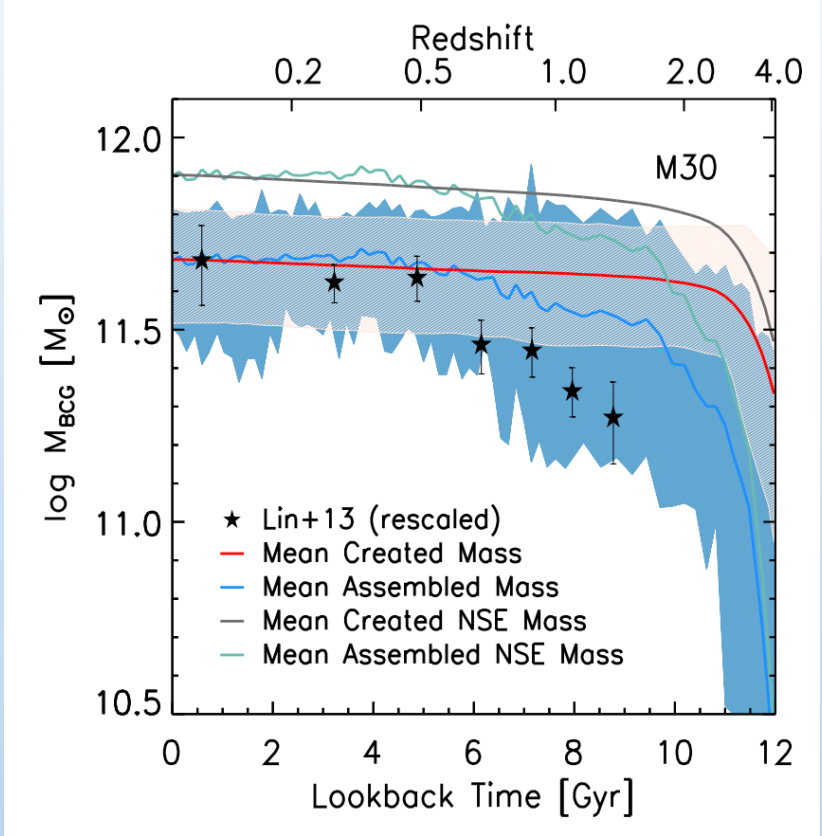
Final stellar mass of BCGs vs cluster mass

- In Ragone-Figueroa+2013 we were over-predicting BCG masses by a factor ≈ 3 at high mass end, similarly to other groups
- Now these predicted masses have been reduced by a factor ≈2, mostly due to a better centering of SMBH particles in the simulations. This is a difficult numerical issue, in particular for cluster sims, still not fully solved.
- On the other hand the observed M have "evolved" by ≈ 1.5 up



Evolution of BCG assembled and created masses

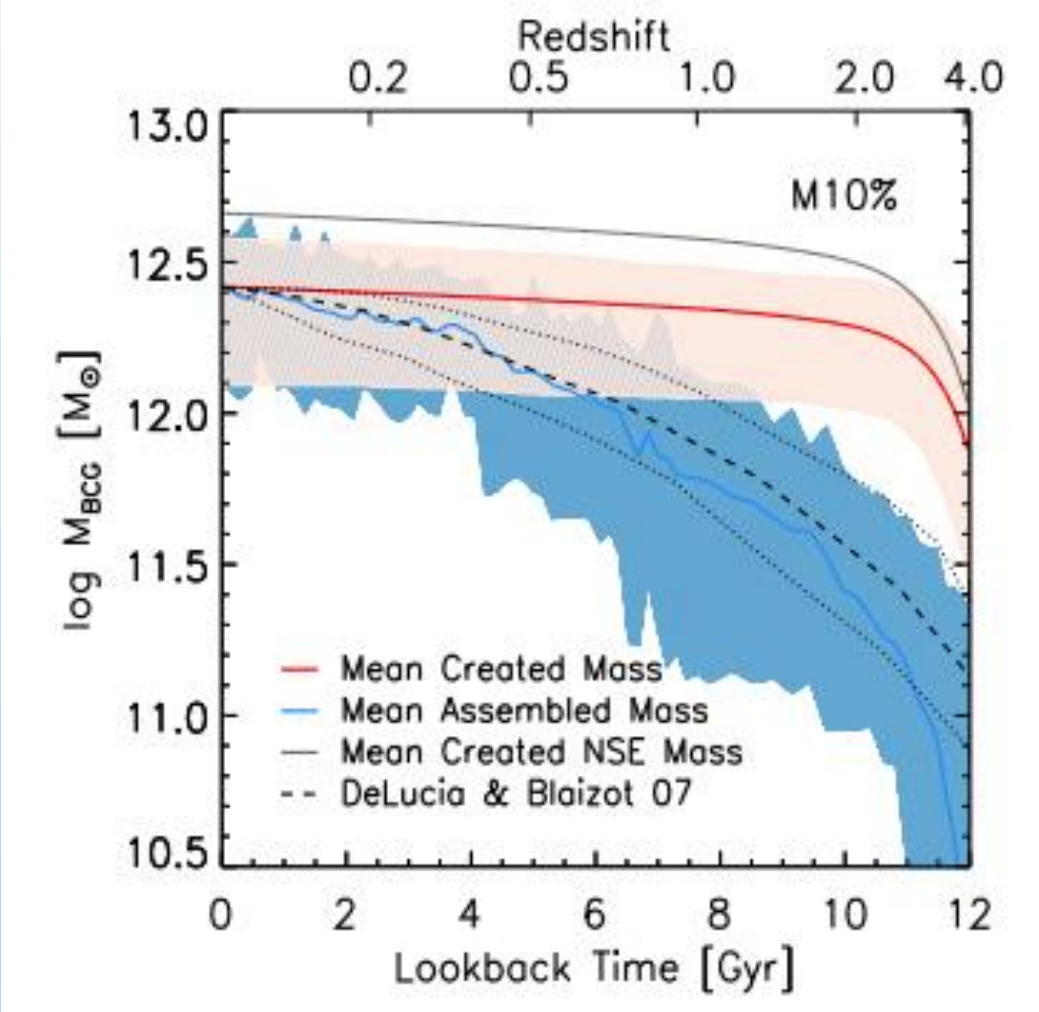




- Observational subsamples at different redshift selected to mimic evolutionary sequences. Compare with evol of assembled mass
- (Lin+13 IRAC shallow clusters "lighter" by a factor ~4. Within 30 kpc we likely loose more mass than data at low z. Imagine to put Lin data also on left plot)
- Anyways, nice agreement (I was surprised)

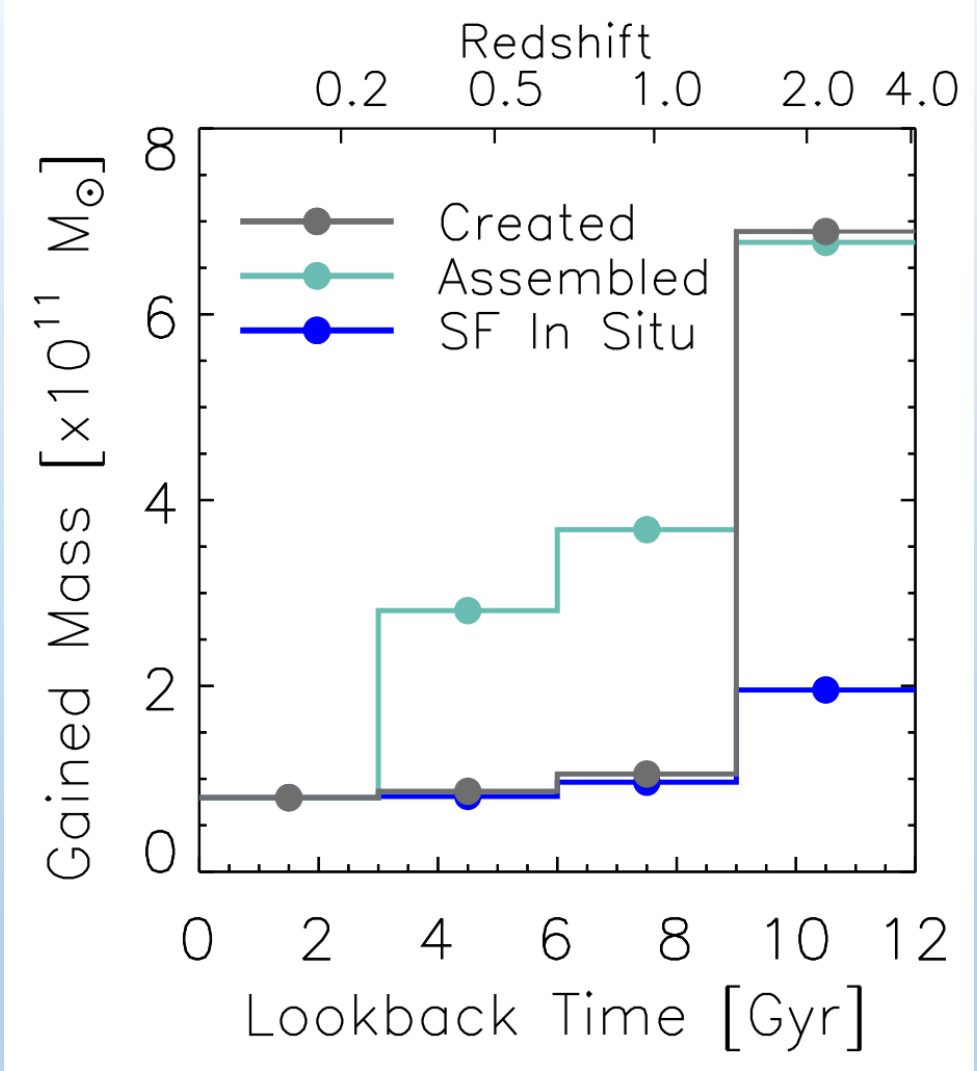
Was DLB07 wrong? Maybe not.

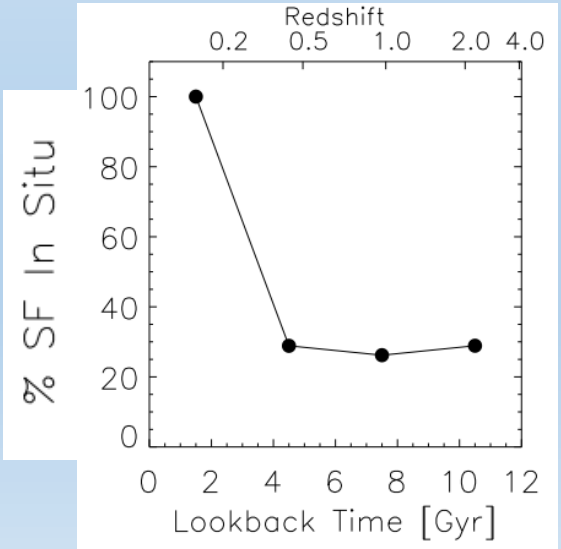
- Simulations in good agreement with SAM growth prediction, if we consider the stellar mass within (say) 10% or R500 (a radius evolving with z)



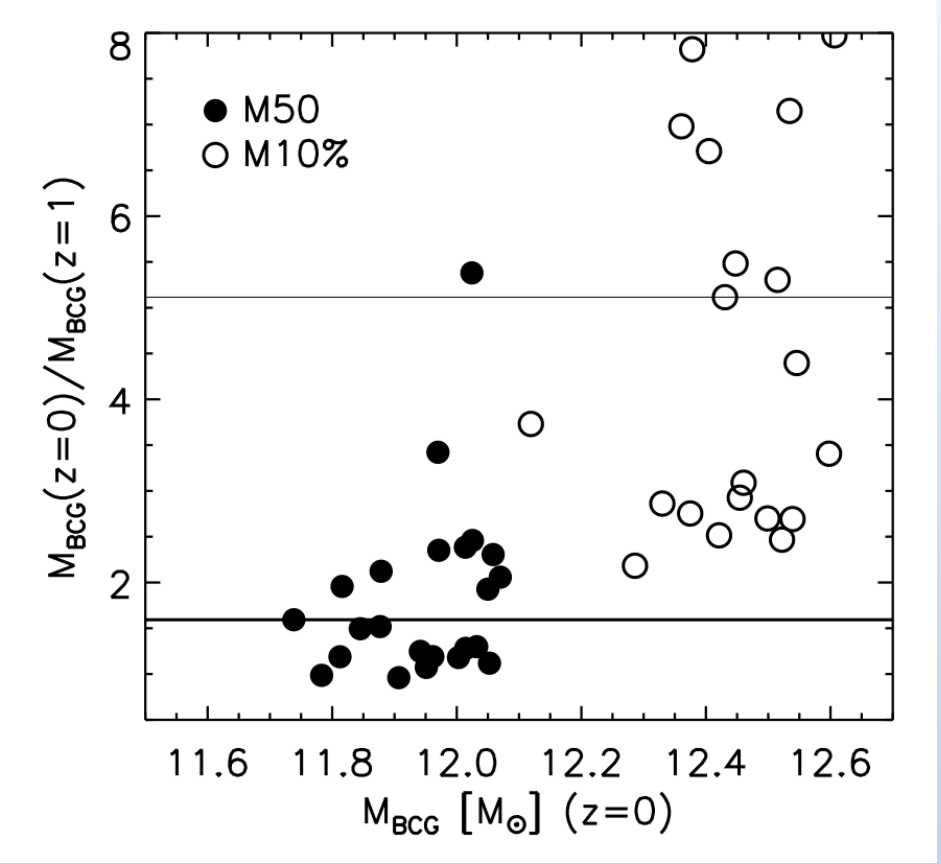
On the importance of in-situ SF

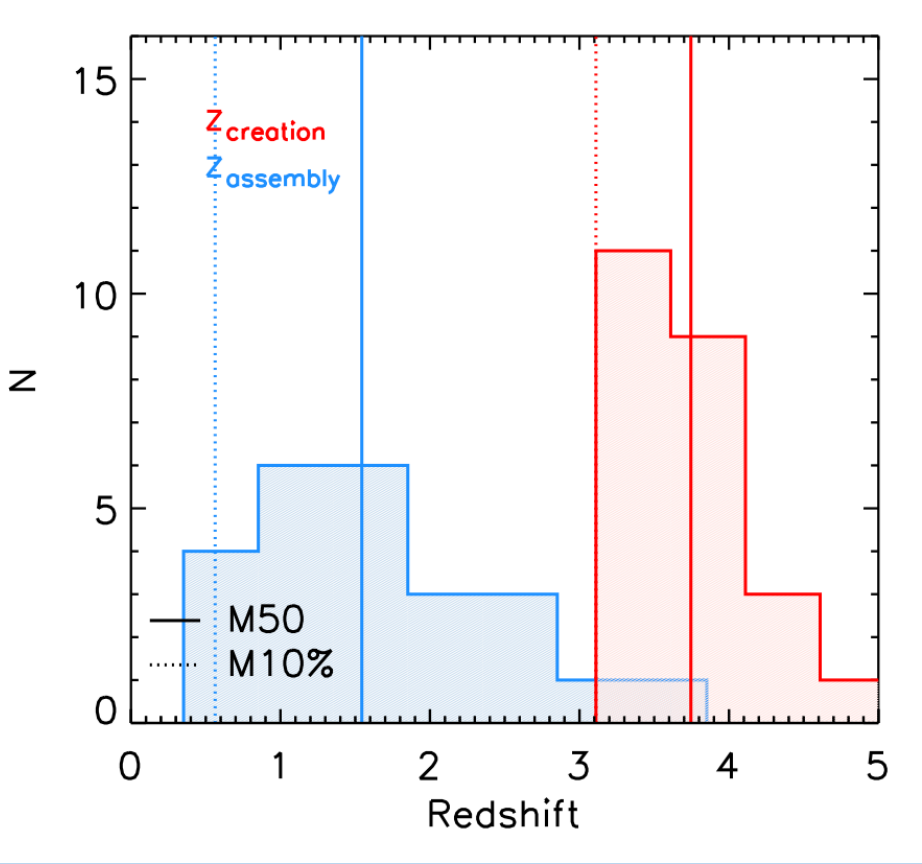
- For most of the evolution, in-situ SF accounts for less than 30% of the growth
- Moreover, SF occurring in satellites that merge at z<1 is almost negligible (late growth by mergers is mostly dry)





Some more statistic





- Median growth factors since z=1 for M(<30kpc), M(<50kpc) and M(<0.1R500) are 1.3, 1.6 and 5 respectively
- Z at which 50% of the final mass within 50 kpc is assembled (created) is 1.5 (3.8)

Hydrodynamical simulations of galaxy clusters including the evolution of dust (another work in conclusion)

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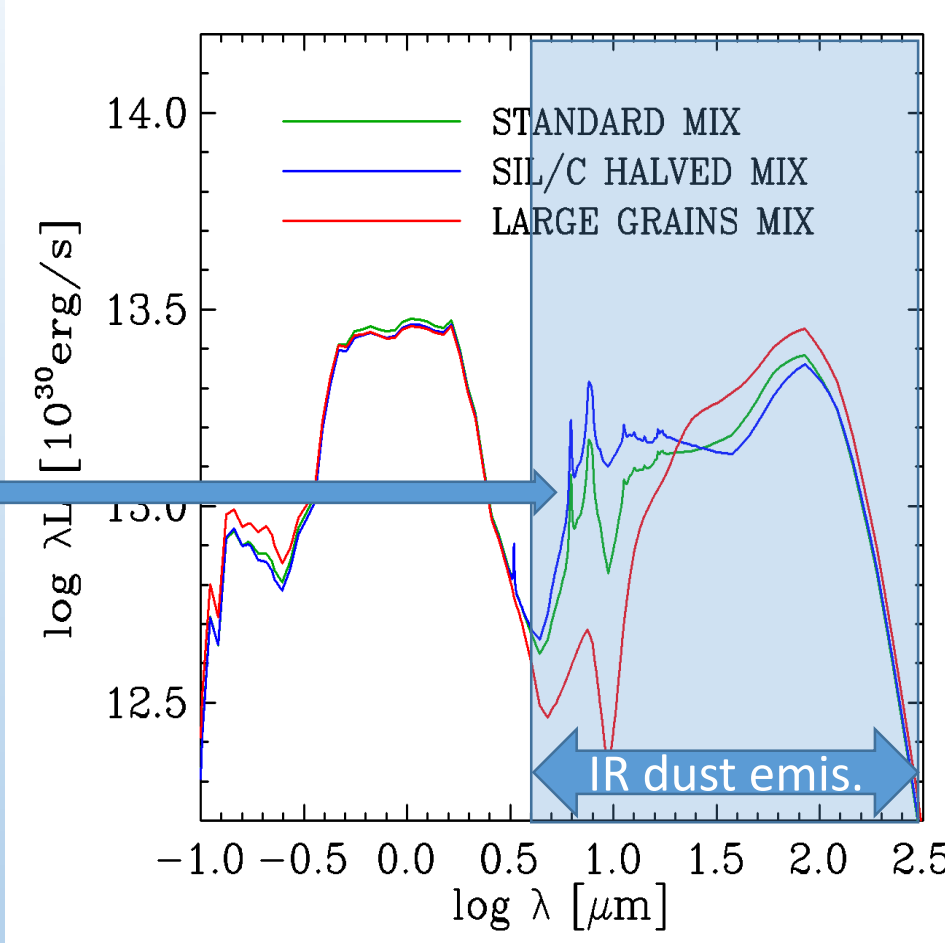
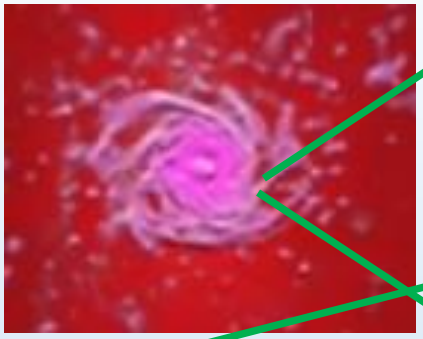
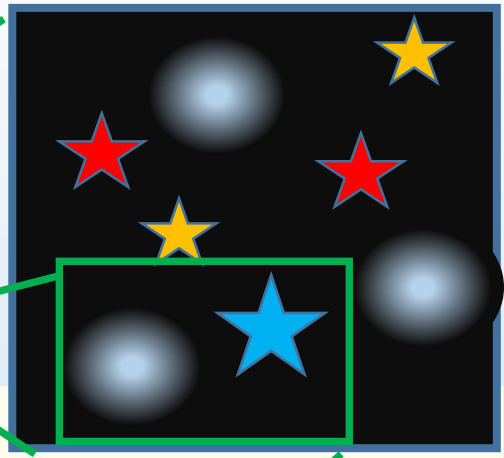
On uncertainties in modelling dust reprocessing

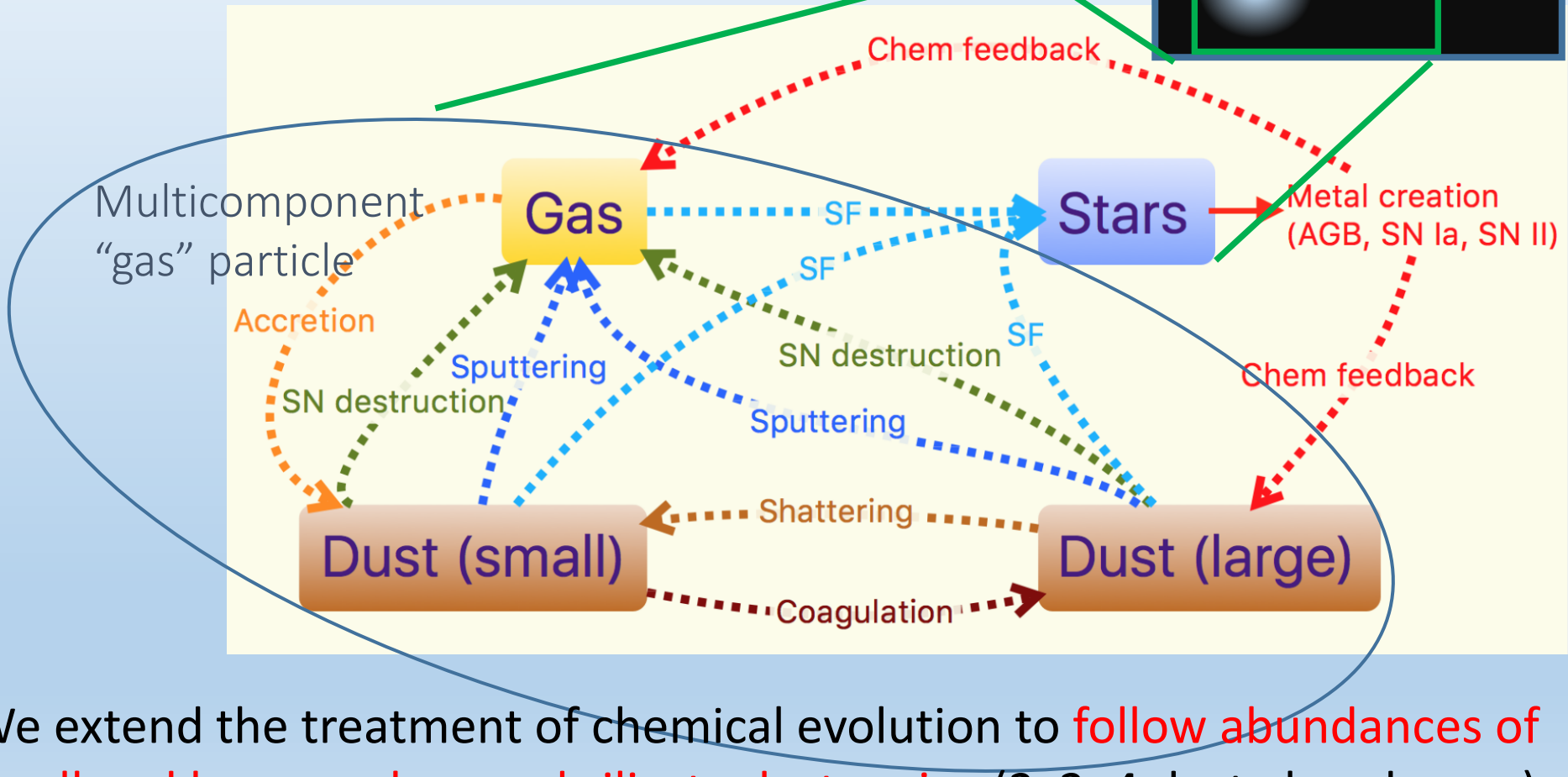
- comparison of simulations with most observations calls for a treatment of dust reprocessing
- Best done with radiative transfer in post-processing (eg. GRASIL3D)
- But effects of dust strongly depend on the composition and size distribution of dust grains
- Most computations adopt the dust grain mixture derived from “average” properties of MW dust
- However properties change from galaxy to galaxy and even within the MW
- Desirable to have a prediction of composition and size distribution from the simulation



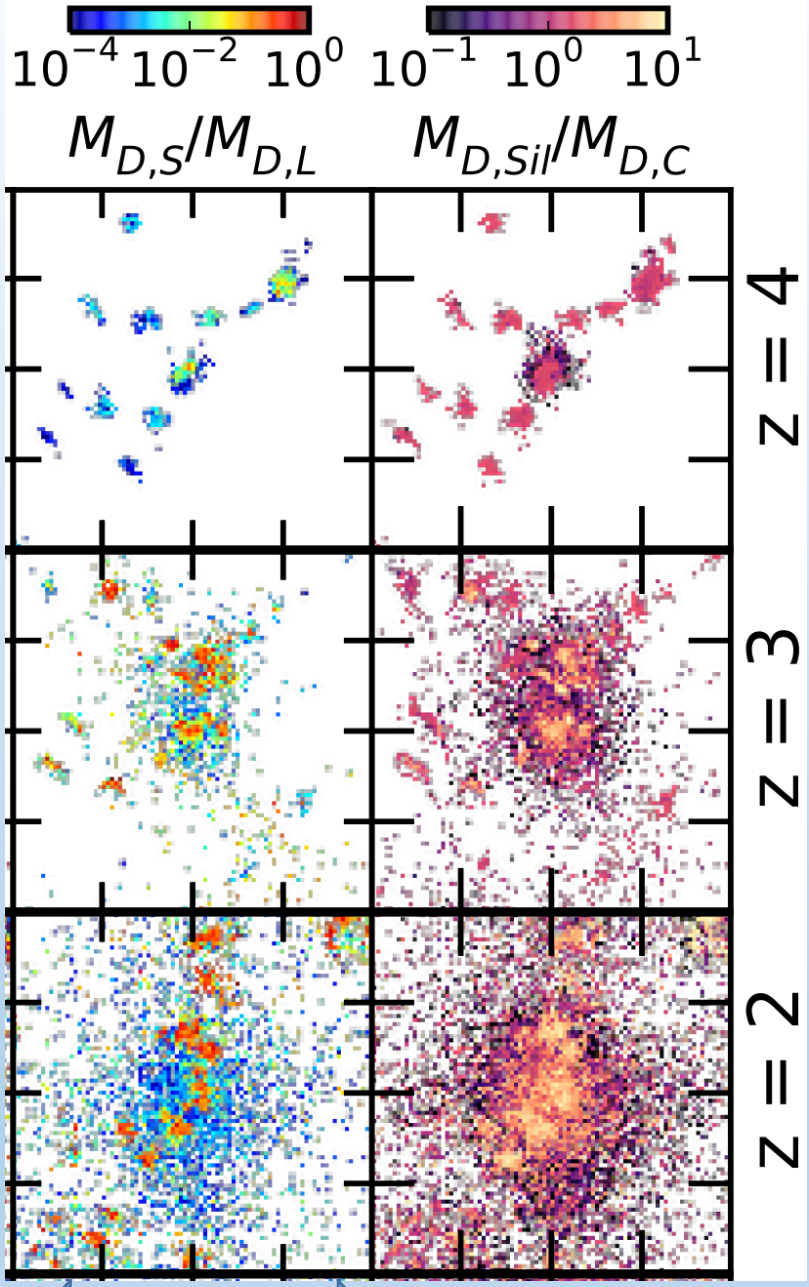
Incorporating dust life cycle in simulations: the scheme



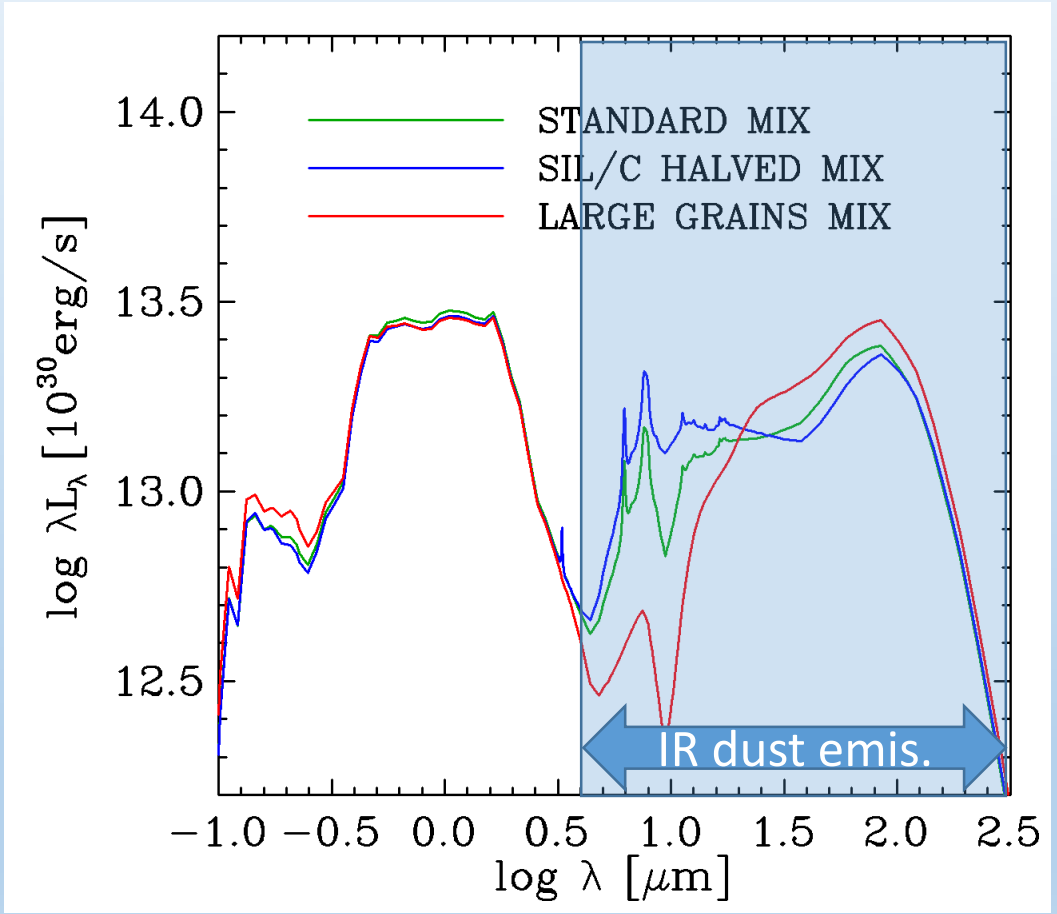




We extend the treatment of chemical evolution to follow abundances of small and large, carbon and silicate dust grains (2x2=4 dust abundances)



Small/Large and SIL/C grain ratios well below "standard" in interesting situations, eg z=4, when SFD is highest IR SED would be strongly affected



Conclusion

- For the first time since I run simulations, my conclusion is not “L'è tutto sbagliato, l'è tutto da rifare!” (Bartali, 1979)

Future perspectives

- Finish these 2 papers ASAP
- Go up in resolution 10x for the whole sample
- Analyze structural and chemical properties

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