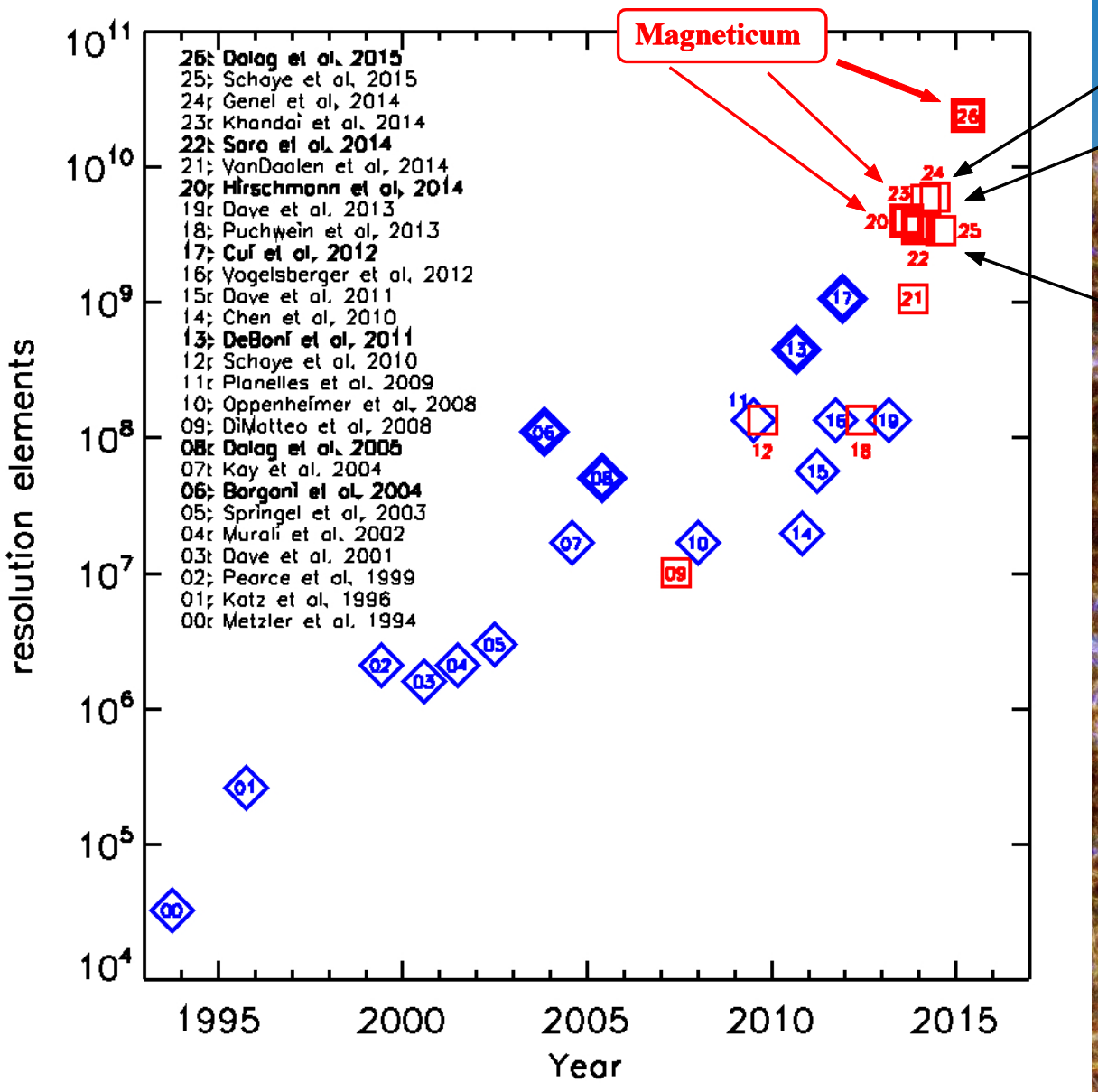
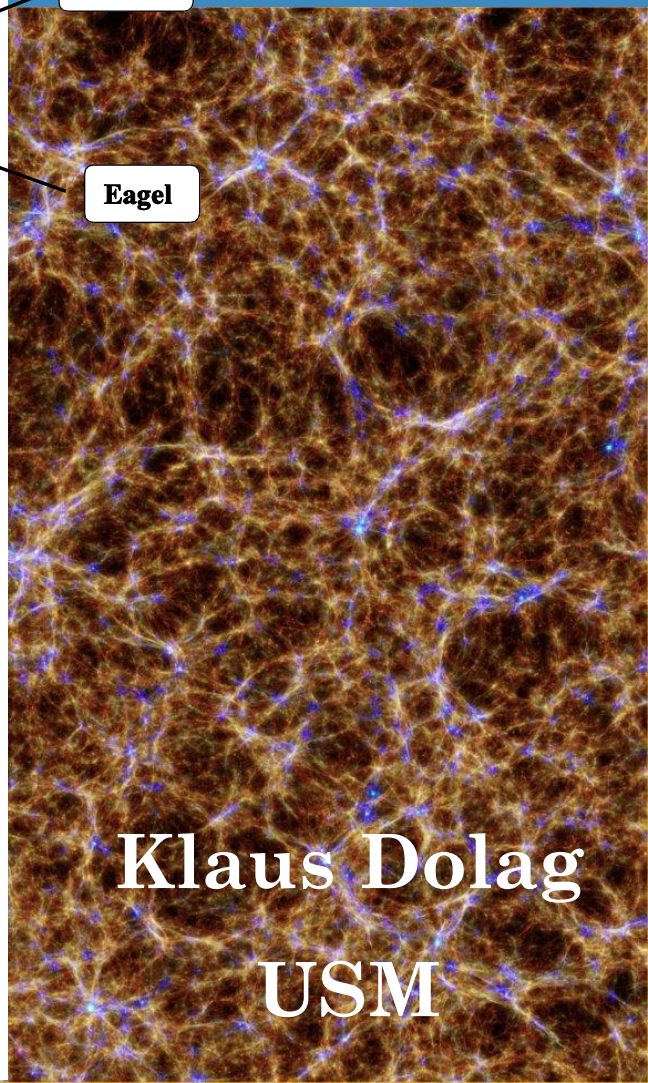
MAGNETICUM



MassiveBalckII

Illustris

Eagel



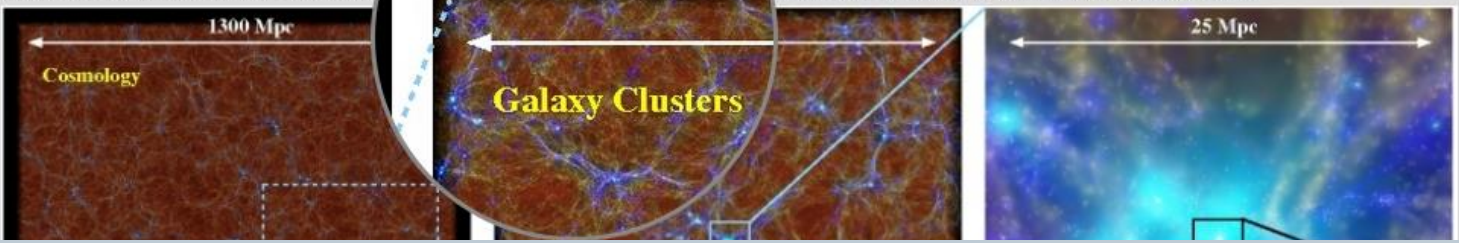
Klaus Dolag

USM

MAGNETICUM

Home | Media | People | Simulations | Science | Publications | Data | VOs | Complements | FAQ

The Magneticum simulations are aiming to follow the formation of cosmological structures over a large range of cosmological scales by performing a set of hydrodynamical simulations of different cosmological volumes, each of them sampled with a very large number of particles providing excellent spacial resolution of the different simulations. We take many physical processes into account to allow detailed comparisons to a variety of multi-wavelength observational data. See Simulations for a detailed description for astrophysicists. Me… FAQ explains how to access data products.



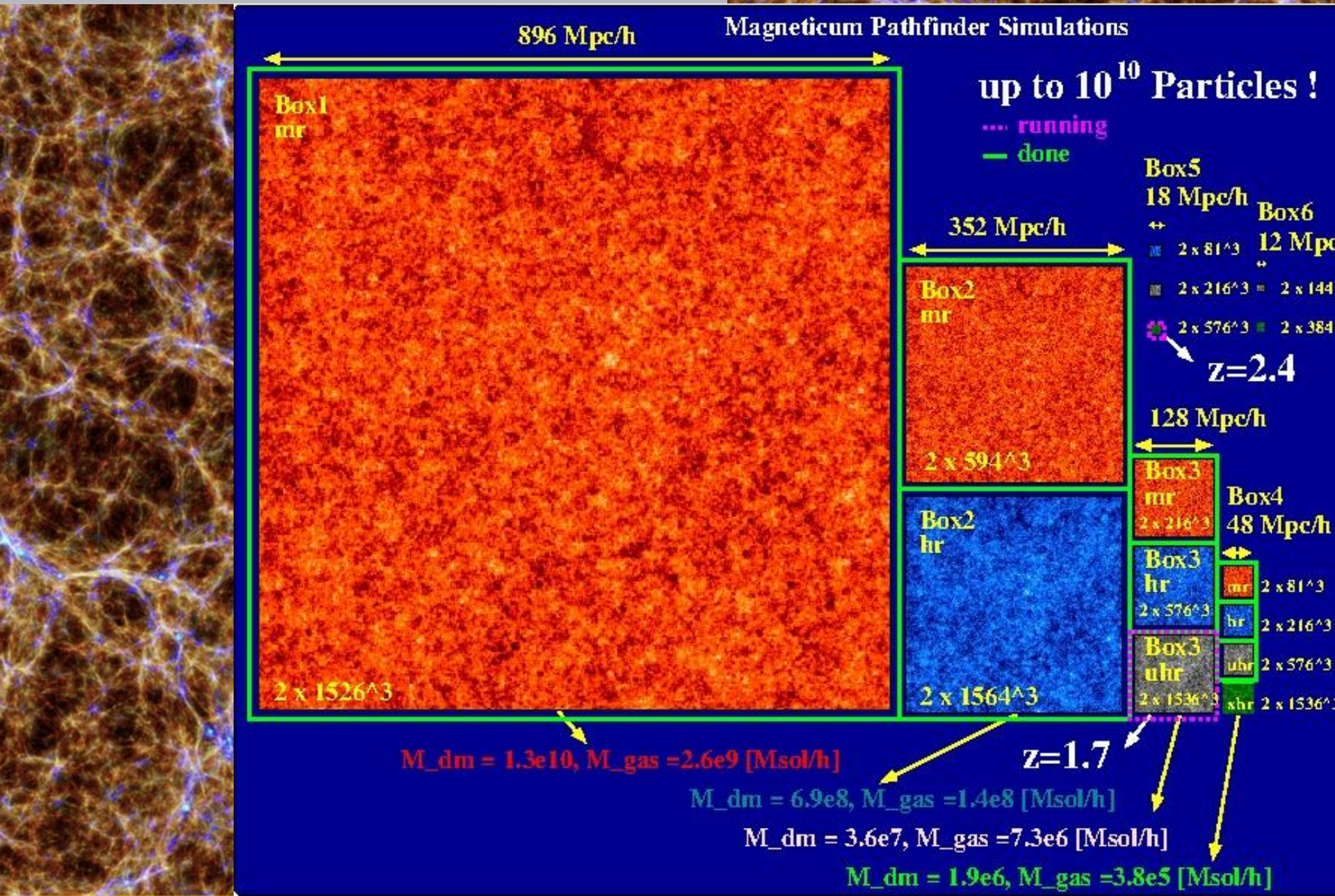
News

- 14.09.2014: Article on refined AGN model submitted
- 25.07.2014: Stereo Movie of *Box2/hr* for LRZ PowerWall made
- 5.06.2014: First 6h production run of *Box0/mr* on SuperMUC
- 24.04.2014:

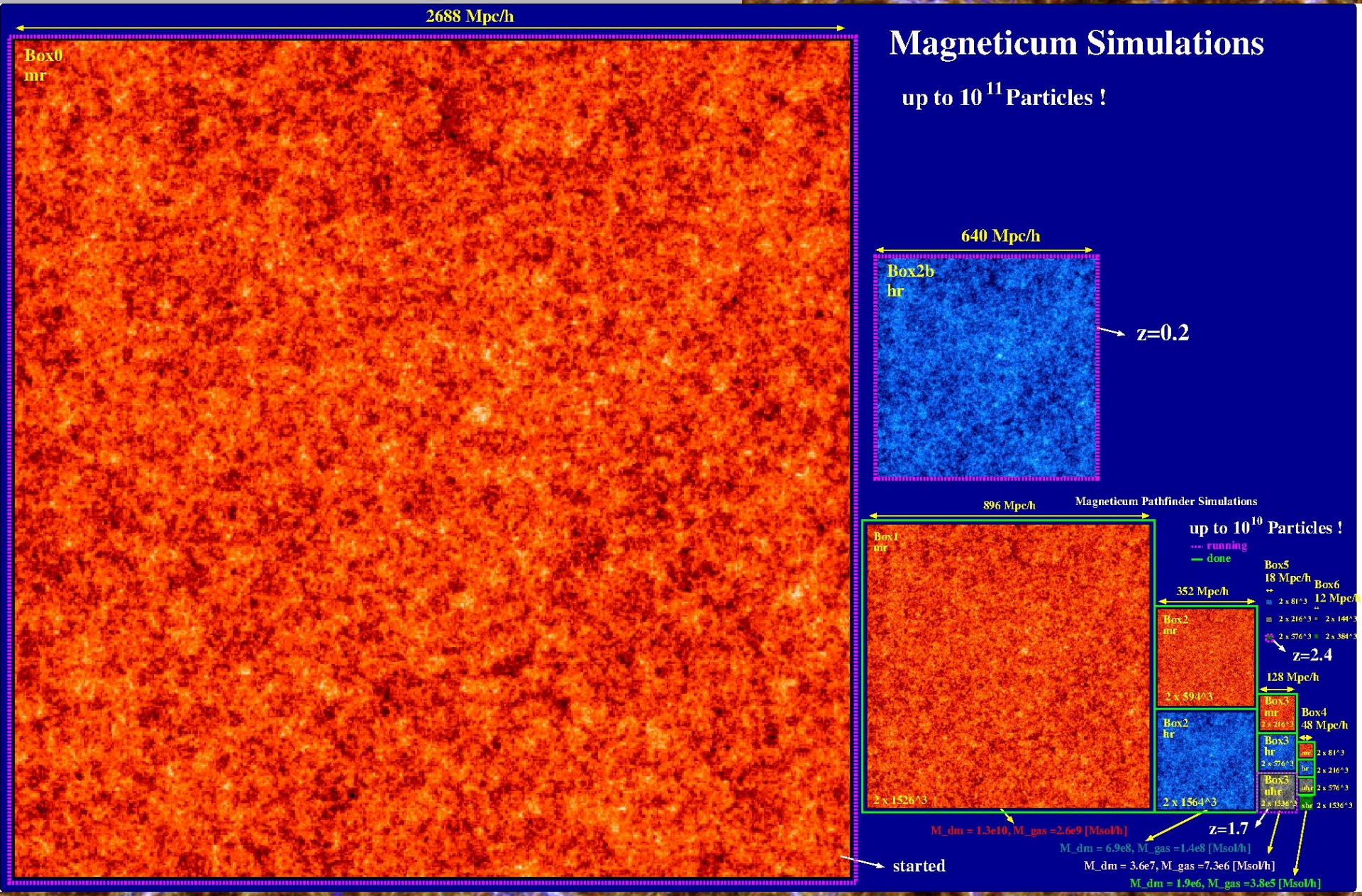
- Redshift-space distortions of galaxies, clusters and AGN: testing how the accuracy of growth rate measurements depends on scales and sample selections
***Marulli, Veropalumbo, Moscardini, Cimatti & Dolag*: submitted to MNRAS**
- Connecting Angular Momentum and Galactic Dynamics: The Complex Interplay between Spin, Mass, and Morphology
***Teklu, Remus, Dolag, Beck, Burkert, Schmidt, Schulze & Steinborn*: submitted to ApJ**
- Baryon impact on the halo mass function: Fitting formulae and implications for cluster cosmology
***Bocquet, Saro, Dolag & Mohr*: submitted to MNRAS**
- An improved SPH scheme for cosmological simulations
***Beck et al.* : submitted to MNRAS**
- The cosmic growth of the active black hole population at 1<z<2 in zCOSMOS, VVDS and SDSS
***Schulze et al. (incl. Hirschmann)*: MNRAS 2015**
- Constraints on the distribution and energetics of fast radio bursts using cosmological hydrodynamic simulations
***Dolag, Gaensler, Beck & Beck*: MNRAS submitted**
- A refined sub-grid model for black hole accretion and AGN feedback in large cosmological simulations
Steinborn, Dolag, Hirschmann, Pr…
- The Redshift Evolution of the Me…
McDonald et al., SPT team (incl. S…
- Cosmological simulations of blac…
Hirschmann, Dolag, Saro, Bachma…
- Constraints on the CMB Tempera…
***Saro et al.*: MNRAS 2014**
- Simulated star formation rate functions at z Â˜ 4-7, and the role of feedback in high-z galaxies
***Tescari, Katsianis, Wyithe, Dolag, Tornatore, Barai, Viel & Borgani*: MNRAS 2014**
- Investigating the velocity structure and X-ray observable properties of simulated galaxy clusters with PHOX
***Biffi, Dolag & Boehringer*: MNRAS 2013**
- Virial scaling of galaxies in clusters: bright to faint is cool to hot
***Wu, Hahn, Evrard, Wechsler & Dolag*: MNRAS 2013**
- Planck intermediate results. V. Pressure profiles of galaxy clusters from the Sunyaev-Zeldovich effect
***Planck Collaboration (incl. Dolag)*: A&A 2013**
- The Dark Halo-Spheroid Conspiracy and the Origin of Elliptical Galaxies
***Remus, Burkert, Dolag, Johansson, Naab, Oser & Thomas*: ApJ 2013**
- On the orbital and internal evolution of cluster galaxies
***Iannuzzi & Dolag*: MNRAS 1012**

www.magneticum.org

Where we are ...


Magneticum Pathfinder Simulations
896 Mpc/h
up to 10^10 Particles !
running
done
Box1
mr
2 x 1526^3
352 Mpc/h
Box2
mr
2 x 594^3
Box2
hr
2 x 1564^3
Box5
18 Mpc/h
2 x 81^3
2 x 216^3
2 x 576^3
Box6
12 Mpc
2 x 144
2 x 384
z=2.4
128 Mpc/h
Box3
mr
2 x 216^3
Box3
hr
2 x 576^3
Box3
uhr
2 x 1536^3
Box4
48 Mpc/h
mr 2 x 81^3
hr 2 x 216^3
uhr 2 x 576^3
xhr 2 x 1536^3
z=1.7
M_dm = 1.3e10, M_gas =2.6e9 [Msol/h]
M_dm = 6.9e8, M_gas =1.4e8 [Msol/h]
M_dm = 3.6e7, M_gas =7.3e6 [Msol/h]
M_dm = 1.9e6, M_gas =3.8e5 [Msol/h]

Where we go ...


2688 Mpc/h
Box0
mr
started
Magneticum Simulations
up to 10^11 Particles !
640 Mpc/h
Box2b
hr
z=0.2
896 Mpc/h
Magneticum Pathfinder Simulations
up to 10^10 Particles !
running
done
Box1
mr
2 x 1526^3
352 Mpc/h
Box2
mr
2 x 594^3
Box2
hr
2 x 1564^3
Box5
18 Mpc/h
Box6
12 Mpc/h
z=2.4
128 Mpc/h
Box3
mr
Box4
48 Mpc/h
Box3
hr
2 x 576^3
Box3
uhr
2 x 1536^3
z=1.7
M_dm = 1.3e10, M_gas =2.6e9 [Msol/h]
M_dm = 6.9e8, M_gas =1.4e8 [Msol/h]
M_dm = 3.6e7, M_gas =7.3e6 [Msol/h]
M_dm = 1.9e6, M_gas =3.8e5 [Msol/h]

What is in ...

Numerics:

New Kernels: WC6

Dehnen et al. 2012

Low viscosity scheme

mr/hr (time dep. alpha)

Dolag et al. 2005

uhr (high order grad.)

Beck et al. 2015

Thermal Conduction

1/20th Spitzer

Dolag et al. 2004

Physics:

cooling+sfr+winds

Springel & Hernquist 2002/2003

metals cooling+SNIa,SNII,AGB

Tornatore et al. 2003/2007, Wiersma et al. 2009

BH+AGN feedback

Springe & Di Matteo 2005, Fabjan et al. 2010, Hirschmann et al. 2014, Steinborn et al. 2015

Post-processing:

SubFind

Springel et al. 2001, Dolag et al. 2009

Galaxy properties

Saro et al. 2006, Nuza et al. 2012

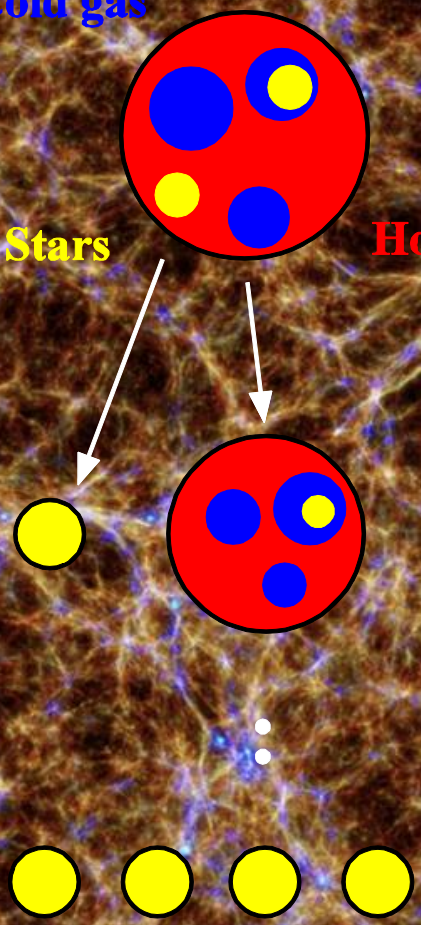
X-Ray Photon data

Biffi et al. 2013/2015

Sub-resolution star-formation:

Multi phase model (sub-scale)

Springel & Hernquist 2002



Star formation

supernova mass fraction

$$\frac{d\rho_\star}{dt} = (1-\beta)\frac{\rho_c}{t_\star}$$

star formation timescale

Cloud evaporation

$$\left.\frac{d\rho_h}{dt}\right|_{evap} = A\beta\frac{\rho_c}{t_\star}$$

cloud evaporation parameter

Growth of clouds

cooling function

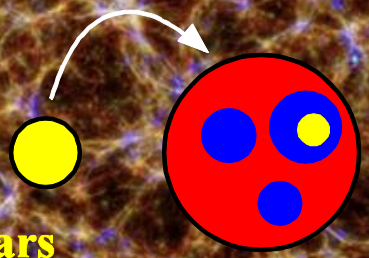
$$\left.\frac{d\rho_c}{dt}\right|_{TI} = -\left.\frac{d\rho_h}{dt}\right|_{TI} = \frac{\Lambda_{net}(\rho_h, u_h)}{u_h - u_c}$$

Chemical enrichment:

Stellar evolution model (sub-scale)

Tornatore et al. 2003/2007

Energy: SNIa, SNII
Metals: SNIa, SNII, AGB winds
H,He,C,Ca,O,N,Ne,Mg
S,Si,Fe,Na,Al,Ar,Ni



Stars

Hot gas

IMF:
Salpeter, Kroupa, Chabrier, Arimoto & Yoshii

Life-time:
Maeder & Meynet 1989
Padovani & Matteucci 1993

Stellar yields:
AGB: Groenewegen, Karakas
SN1a: Thielemann
SNII: Woosly & Weaver
Romano, Kobayashi, ...

SNIa rate:

fraction of stars in binary systems

star-formation rate

$$R_{\mathrm{SN\,Ia}}(t) = A \int_{M_{\mathrm{B,inf}}}^{M_{\mathrm{B,sup}}} \phi(m_{\mathrm{B}}) \int_{\mu_{\mathrm{m}}}^{\mu_{\mathrm{M}}} f(\mu)\, \psi(t - \tau_{m_2})\, \mathrm{d}\mu\, \mathrm{d}m_{\mathrm{B}}$$

distribution of mass-ratios in binary systems

mass range of SN1a binary systems (0.8-8Msol)

SNII and AGB rate:

$$R_{\mathrm{SN\,II|ILMS}}(t) = \phi(m(t)) \times \left(-\frac{\mathrm{d}m(t)}{\mathrm{d}t}\right)$$

Initial mass function (IMF):

$$\phi(m) = dN/d\log m$$

Life-time of stars

$$\tau(m) = \begin{cases} 10^{[(1.34-\sqrt{1.79-0.22(7.76-\log(m))})/0.11]-9} & \text{for } m \leq 6.6\ \mathrm{M}_{\odot} \\ 1.2m^{-1.85} + 0.003 & \text{otherwise.} \end{cases}$$

Sub-resolution SMBH-formation:

Black Hole model (sub-scale)

Springel & Di Matteo 2006

Seeding

Constant seeding
Seeding on m-sigma

Accretion on BH

α -Bondi (Springl & Di Matteo 06)
β -Bondi (Booth & Schaye 09)
cold/hot (Bachmann et al. 14)
....

Feedback

Thermal (Springel & Di Matteo 06)
Bubbles (Sijacki et al. 07)
Mass dependent (Bachmann et al. 14)
....

Merging

Instant merging
Based on velocity
....

Growth of Black Hole

$$\dot{M}_{\rm B} = \alpha \times 4\pi R_{\rm B}^2 \rho c_s \simeq \frac{4\pi\alpha G^2 M_\bullet^2 \rho}{(c_s^2 + v^2)^{3/2}}$$

gas density

sound speed

$$\dot{M}_\bullet = \min(\dot{M}_{\rm B}, \dot{M}_{\rm Edd})$$

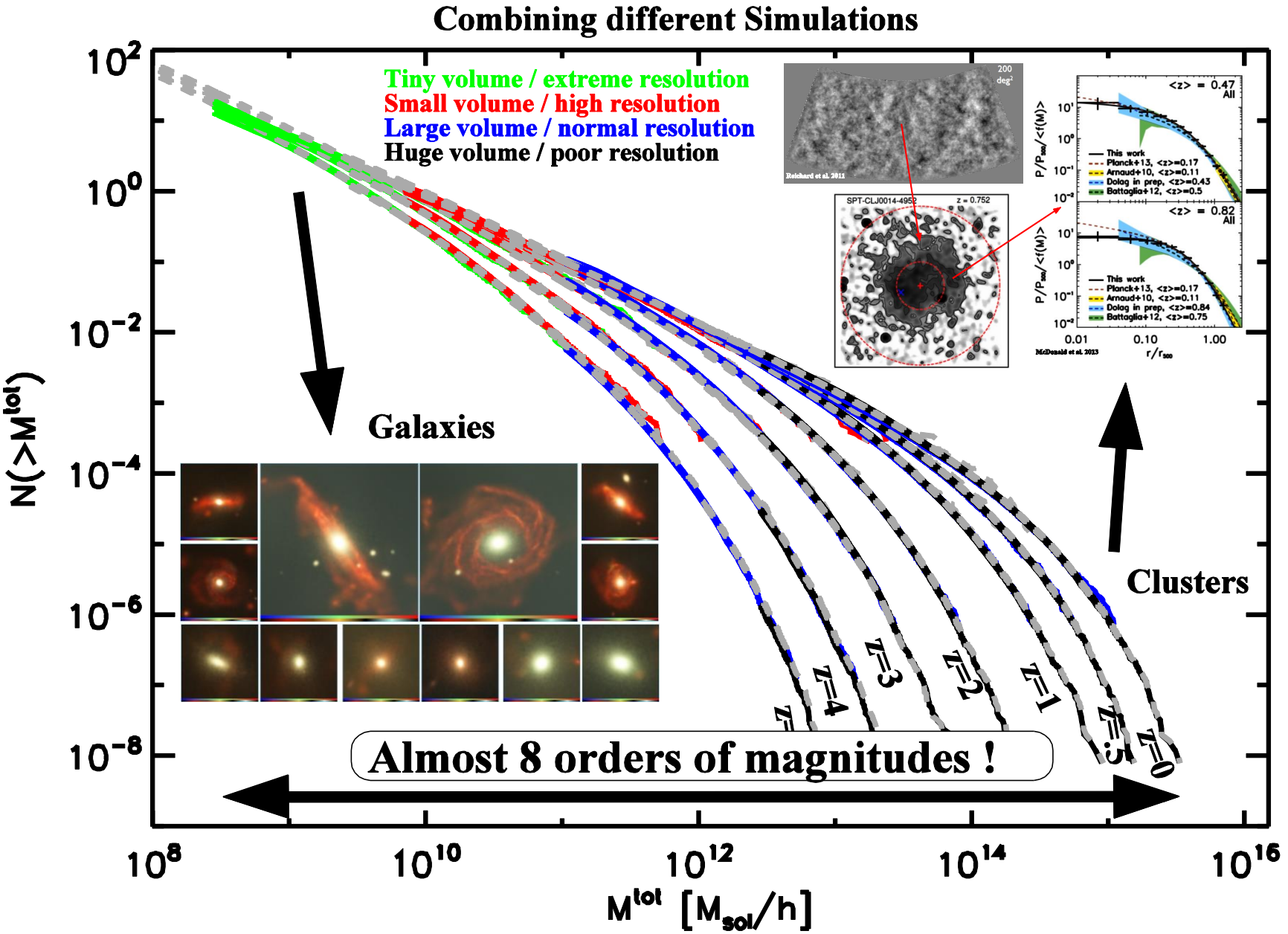
Feedback by Black Holes

$$L_{\rm bol} = 0.1 \times \dot{M}_\bullet c^2$$

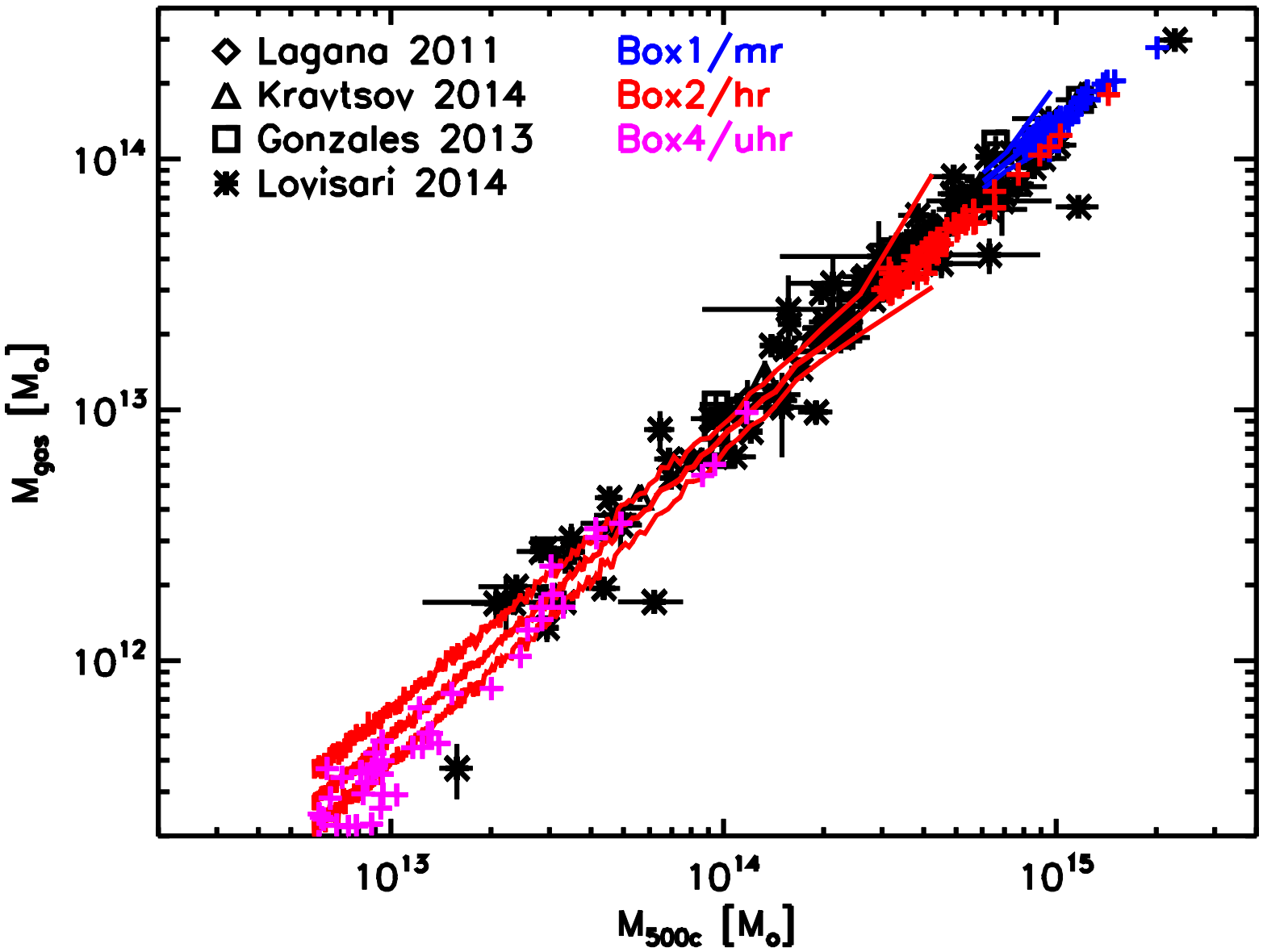
$$\dot{E}_{\rm feedback} = f \times L_{\rm bol}$$

efficiency

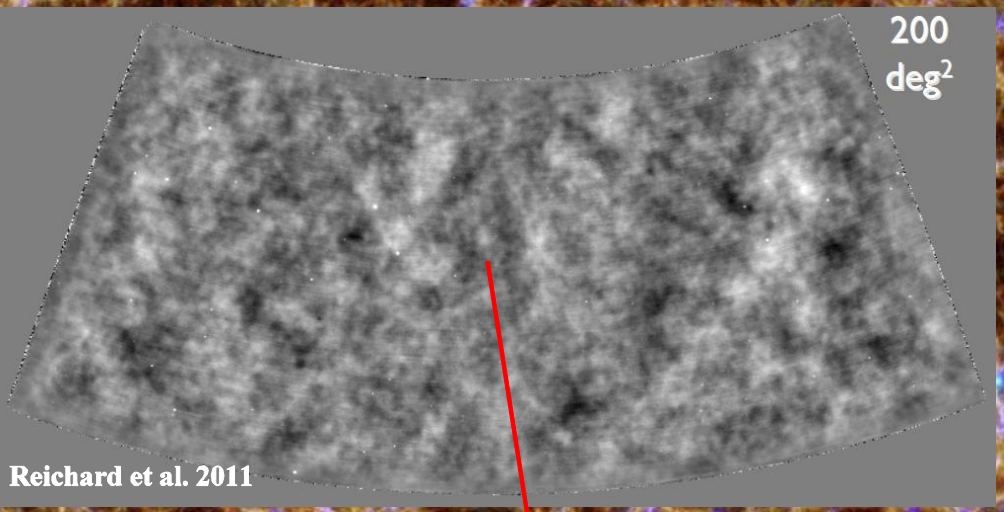
What can we do ...



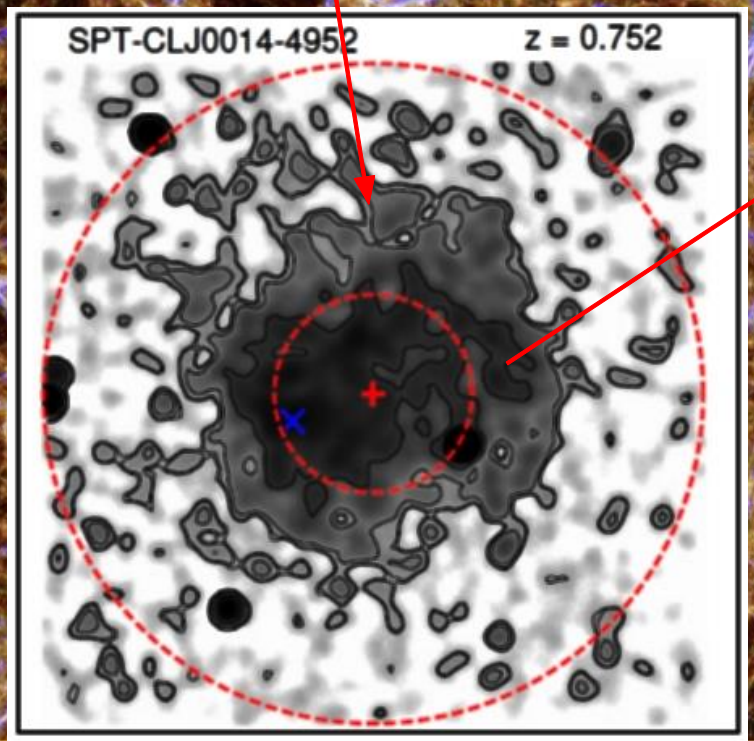
Gas mass of halos

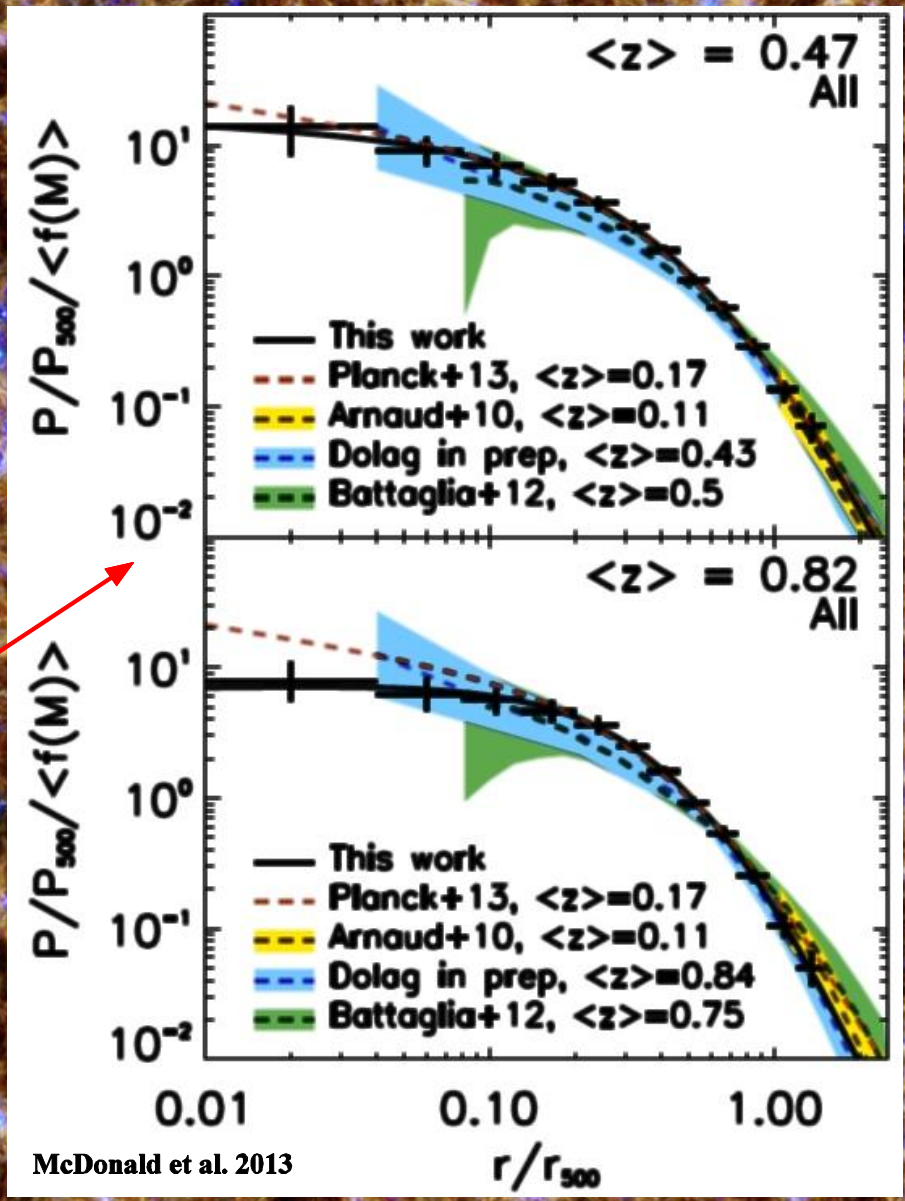


Presssure profiles of clusters



Reichard et al. 2011

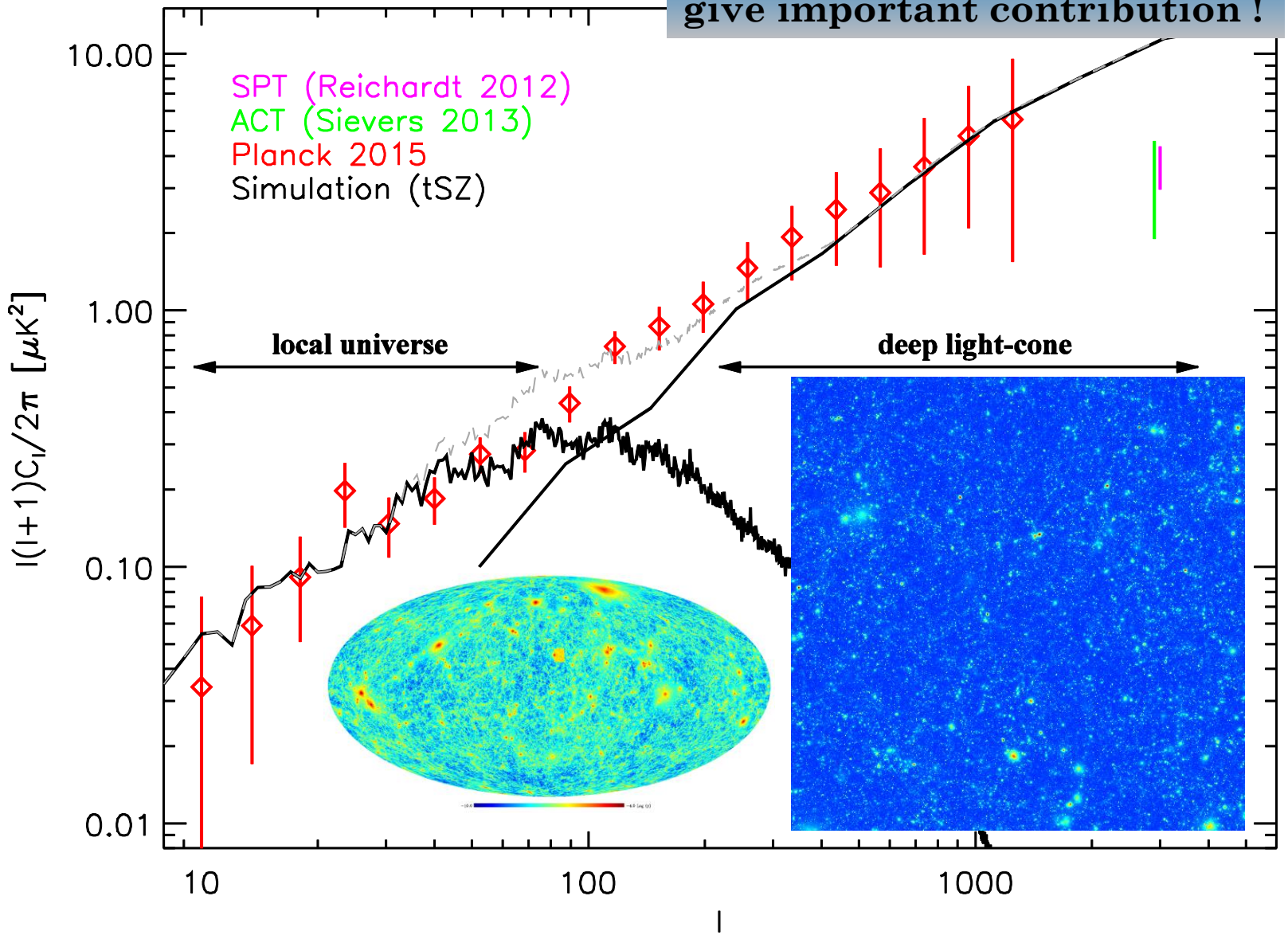




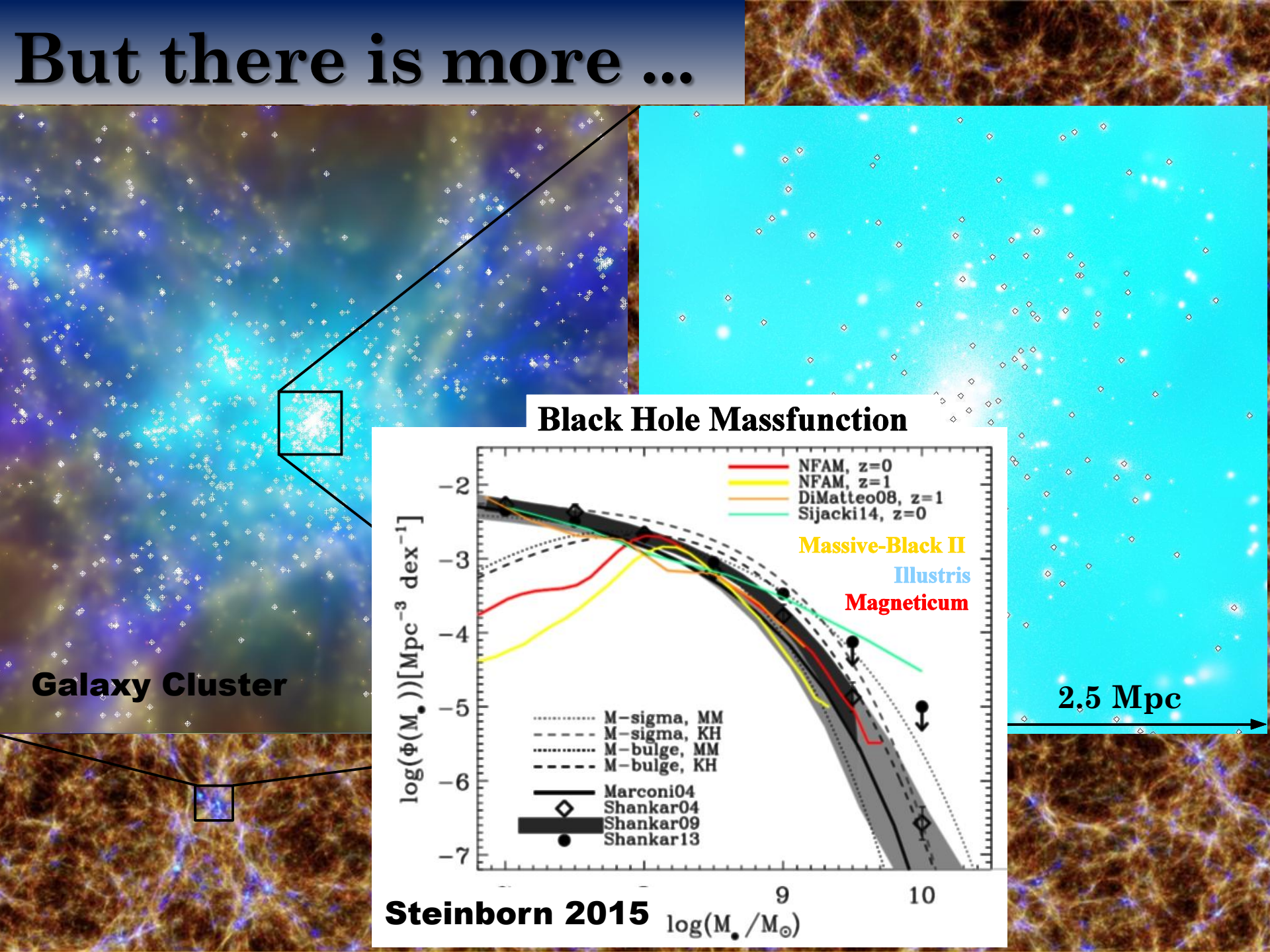
McDonald et al. 2013

SZ power spektrum

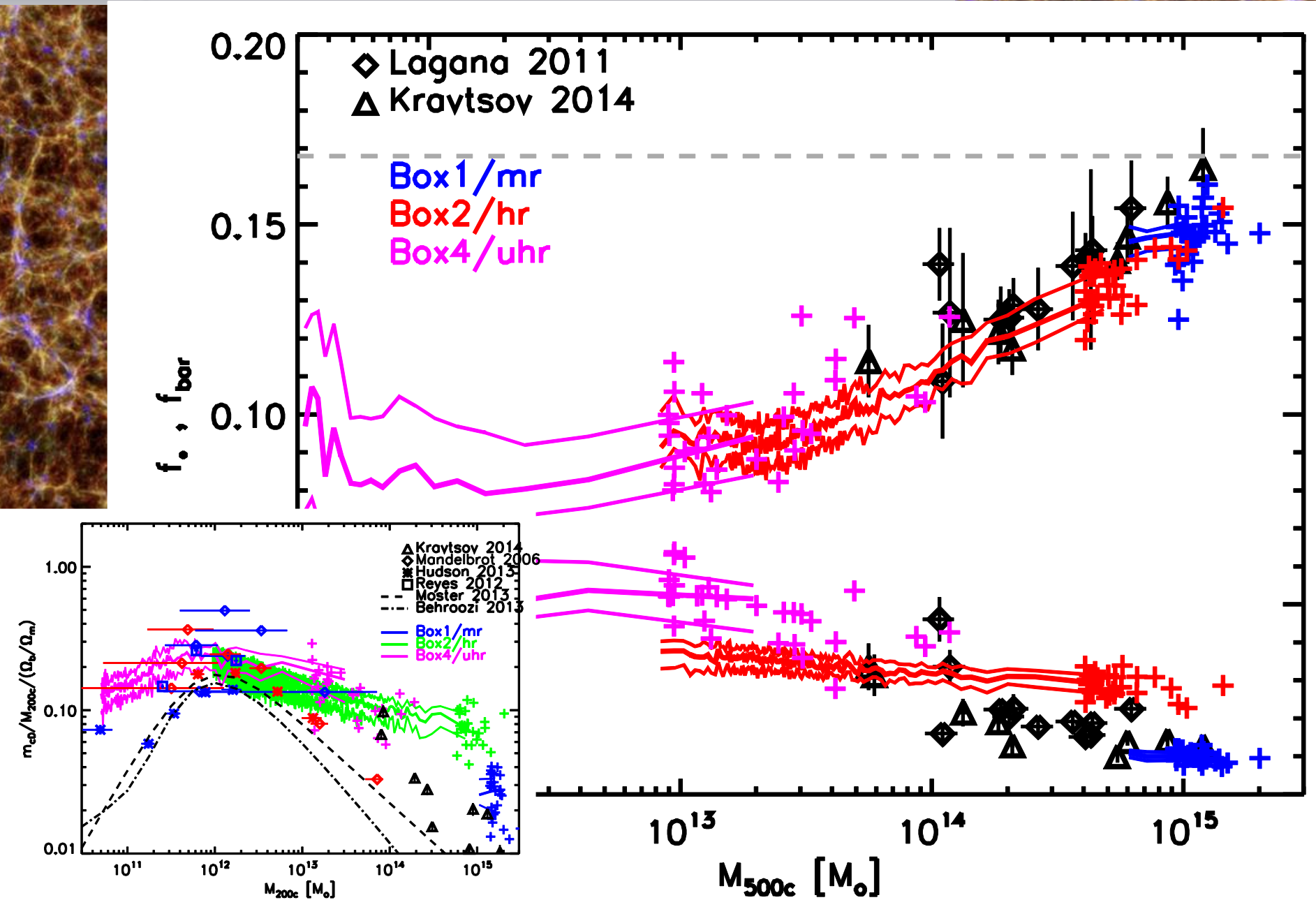
Local Universe simulations give important contribution !



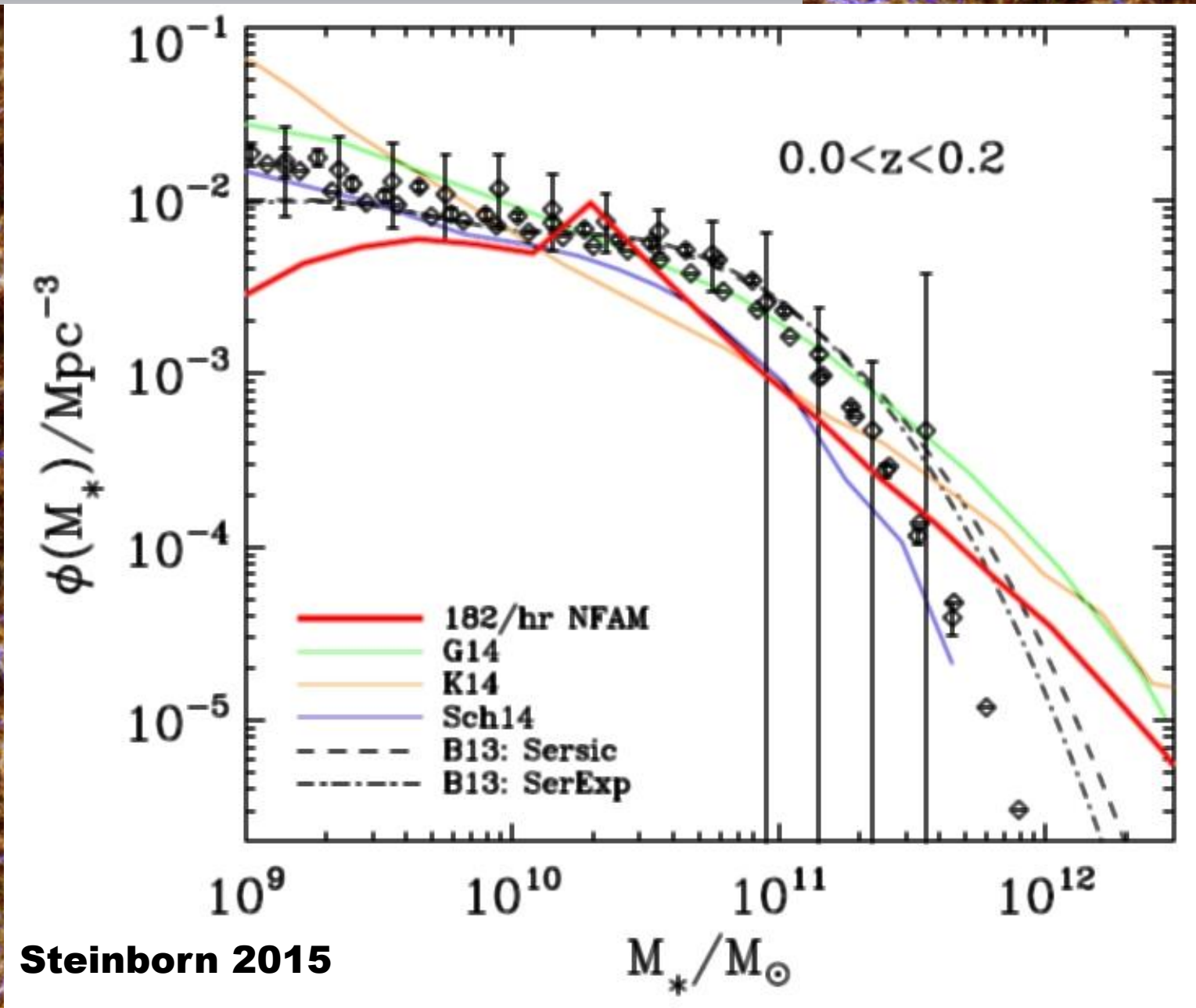
But there is more ...



Baryon conversion in halos:

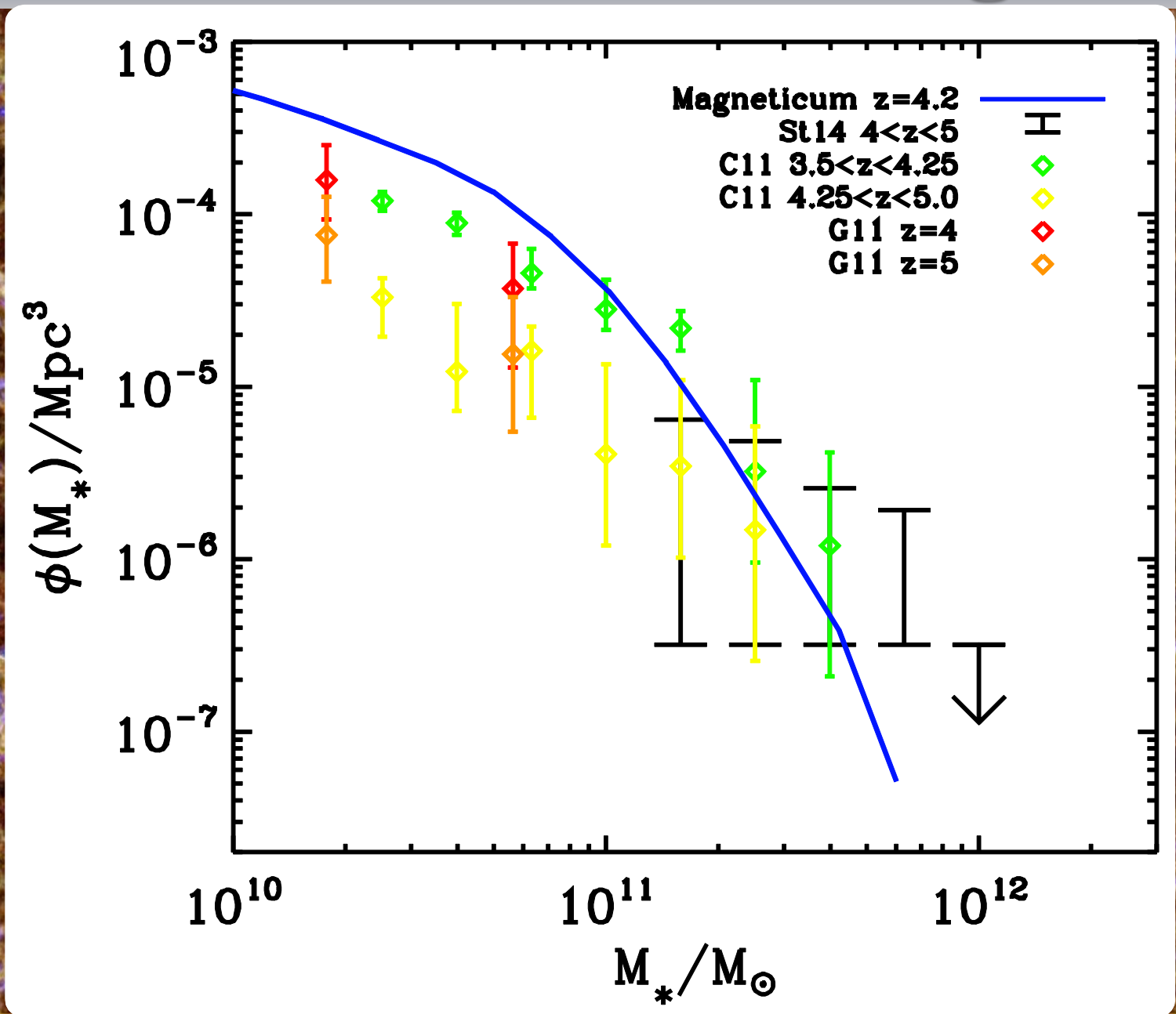


Stellar mass function

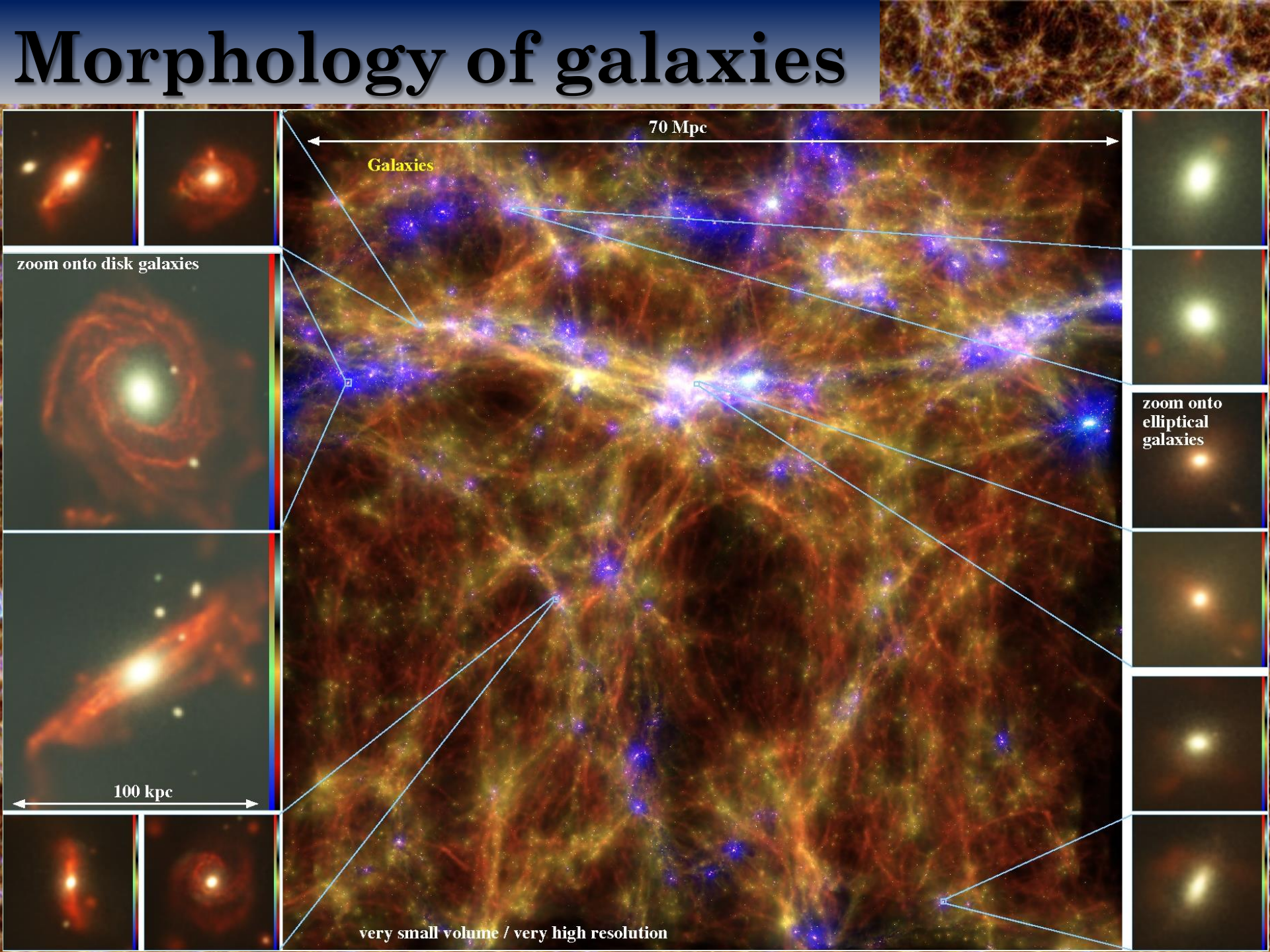


Steinborn 2015

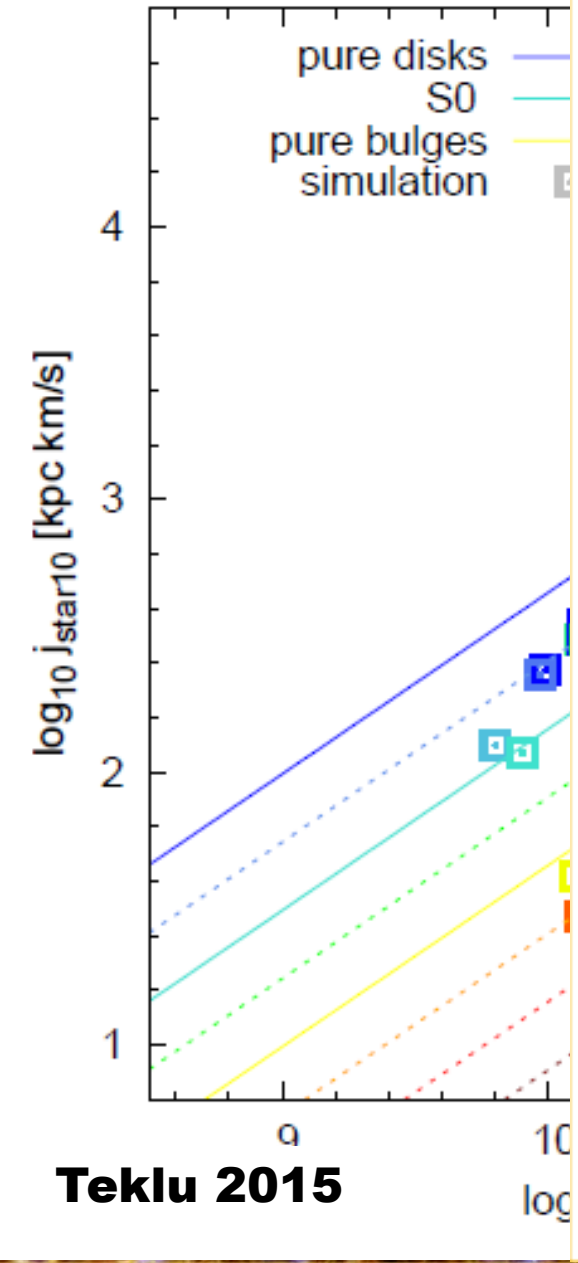
Stellar mass function at high z



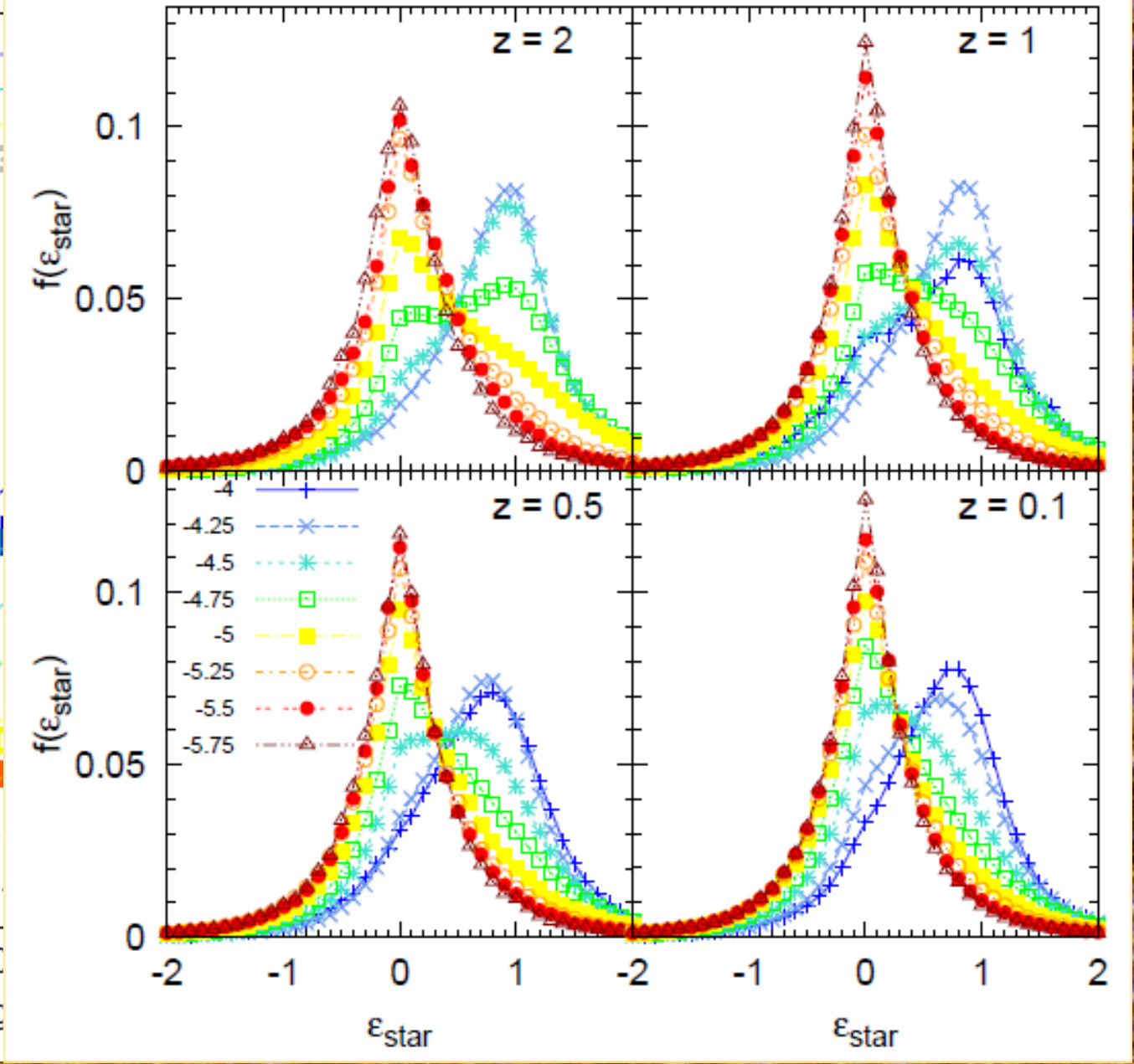
Morphology of galaxies



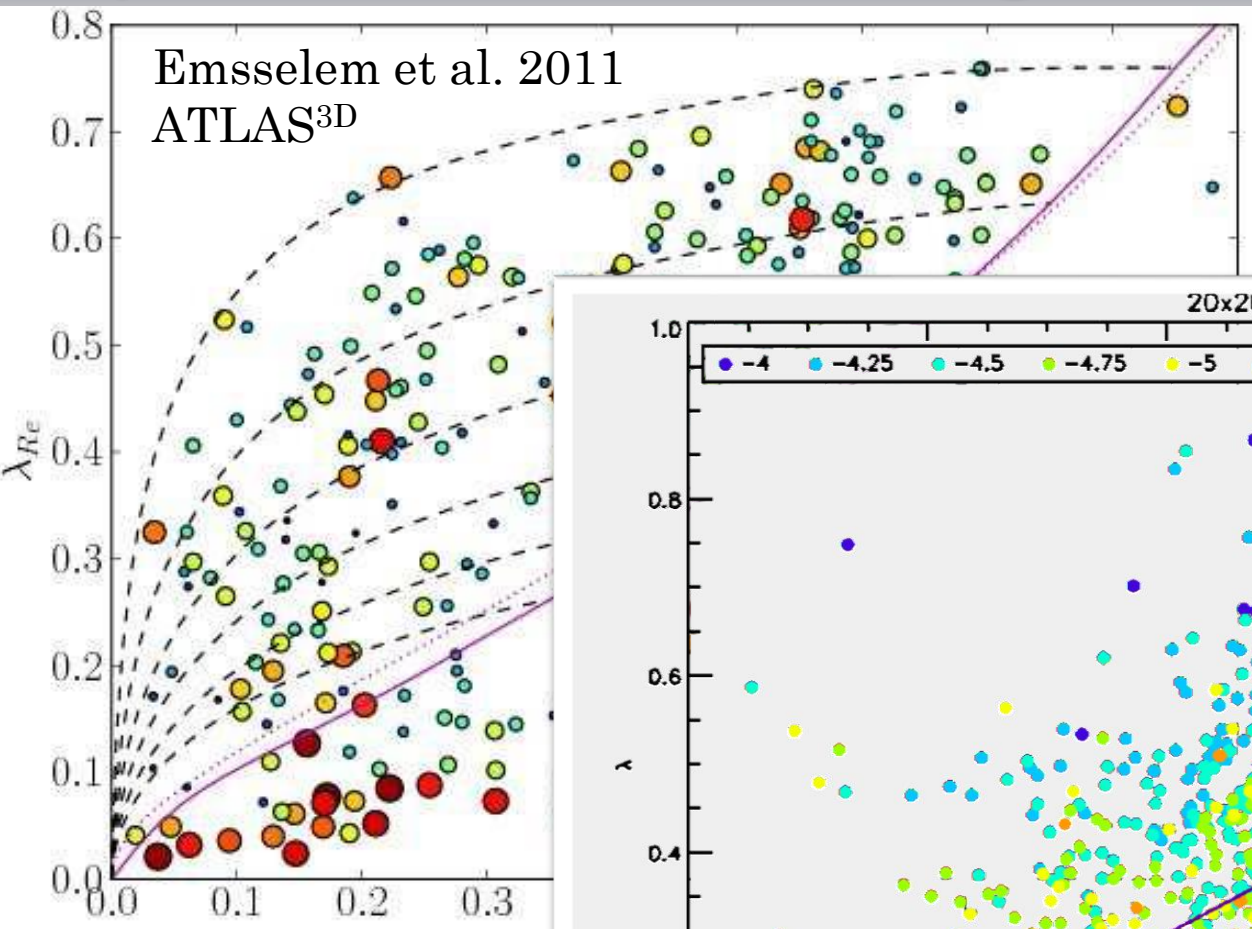
Dynamics of closeby galaxies

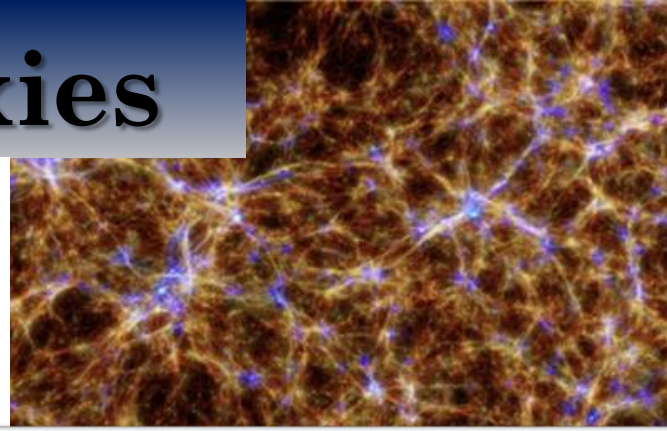


Teklu 2015

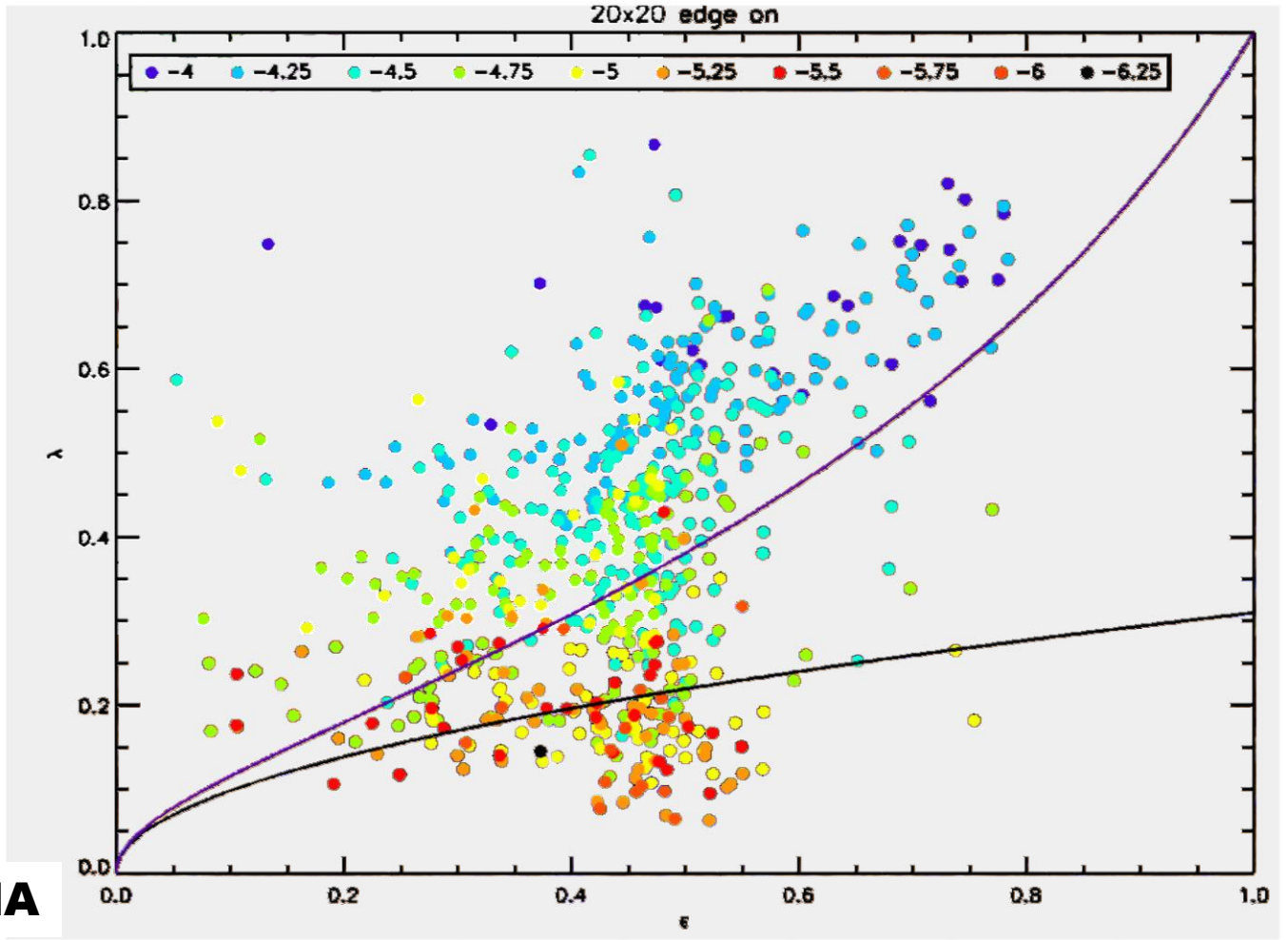


Dynamics of local galaxies



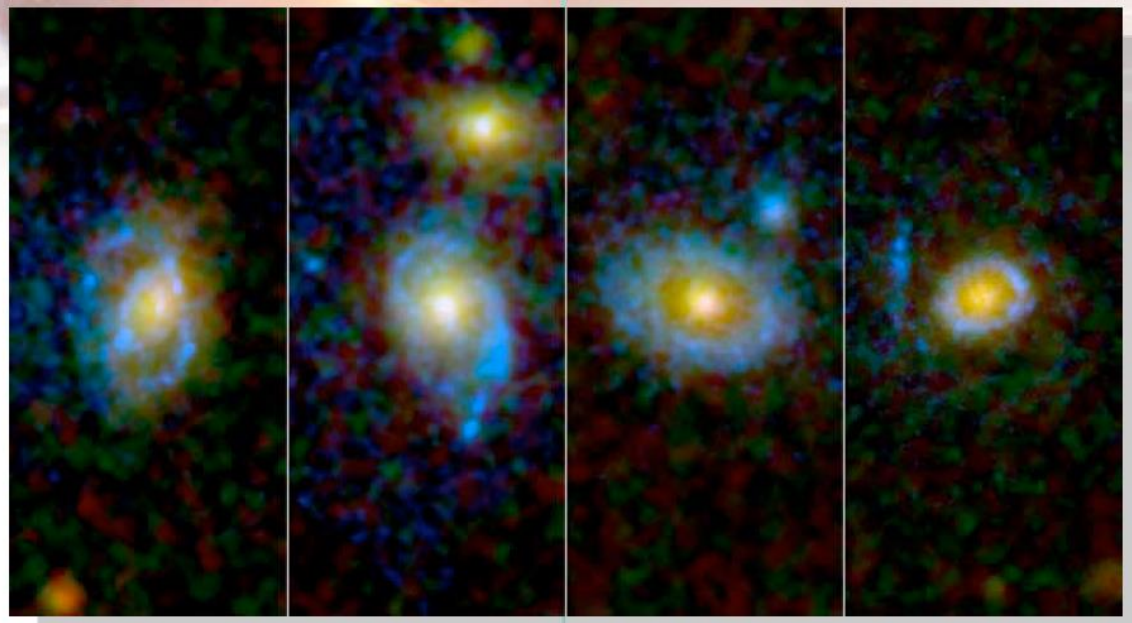


F. Schulze, MA

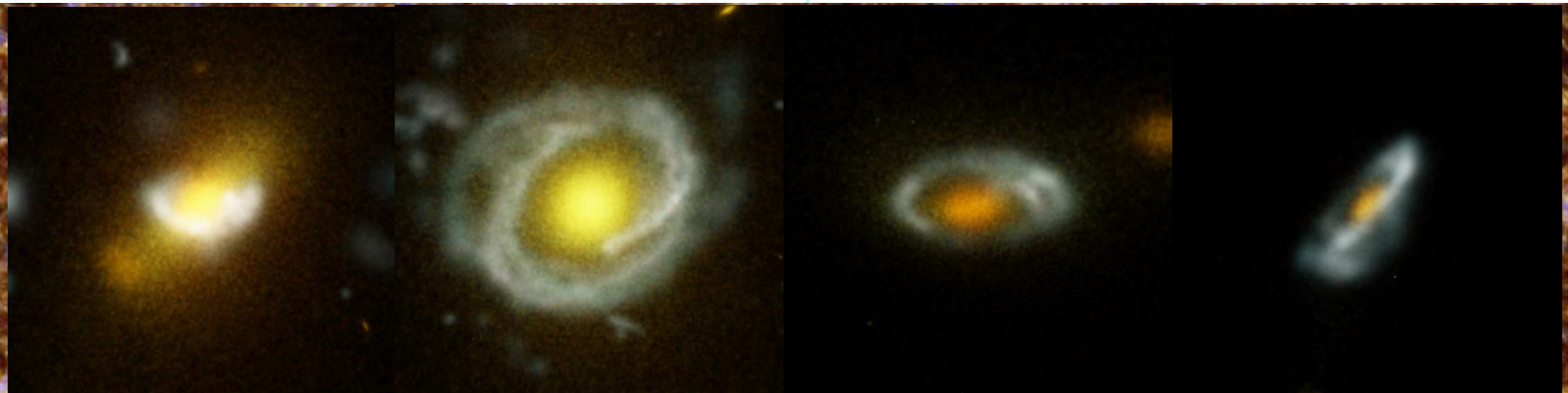


Rings arround Ellipticals

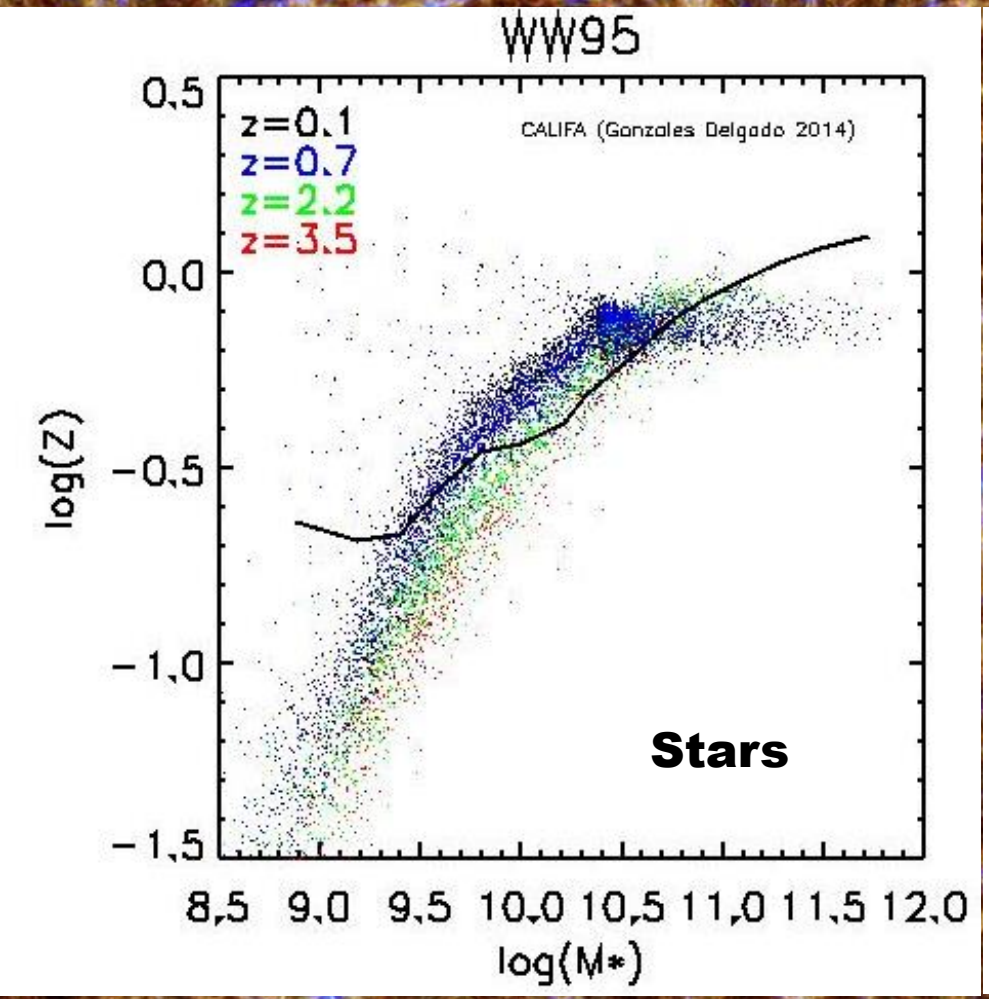
Giant Ultraviolet Rings Found in Resurrected Galaxies

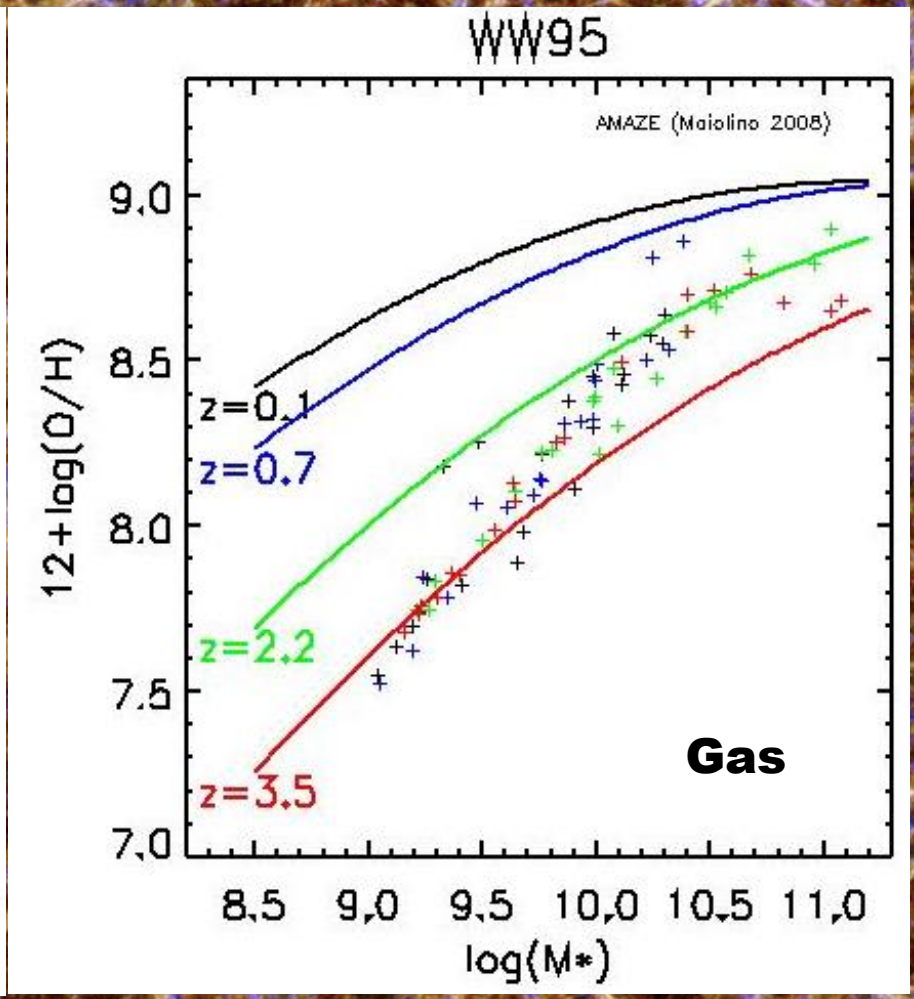


On August 11, 2010, astronomers using JPL's Galaxy Evolution Explorer (GALEX) and the Hubble Space Telescope (HST) announced the discovery of huge ultraviolet light-emitting rings surrounding elliptical



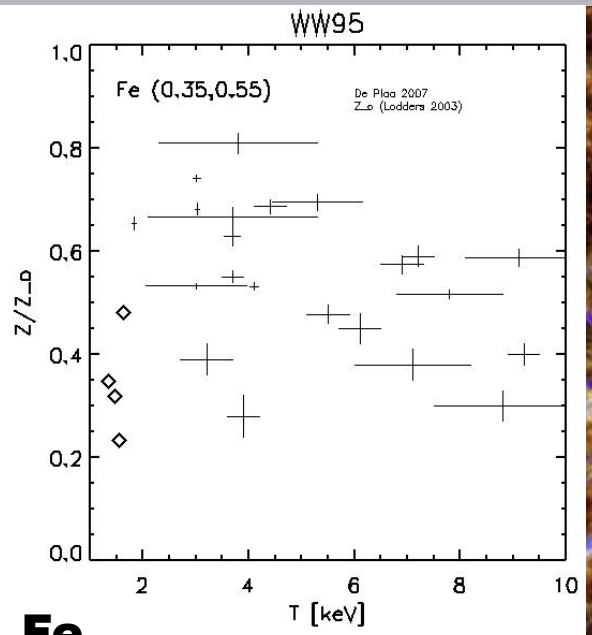
How does the enrichment work ?



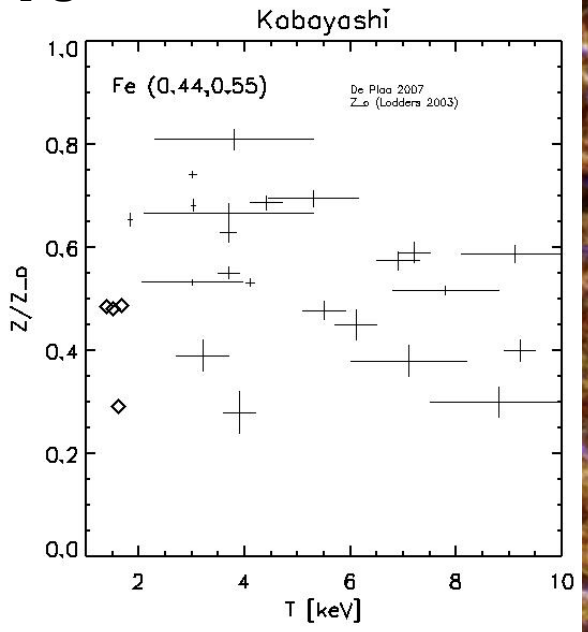


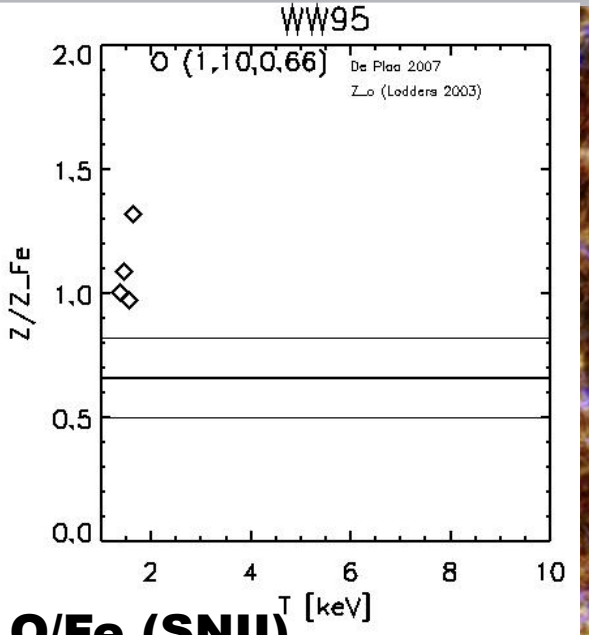
Total metal content (Galaxies)

Metal composition in the ICM ?

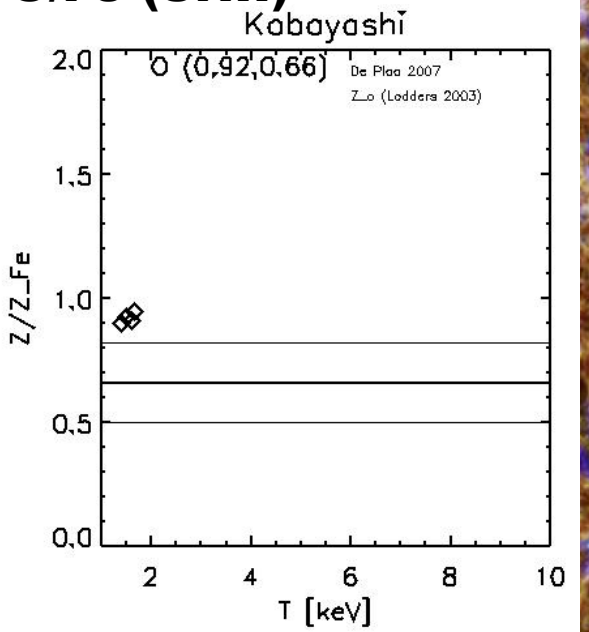


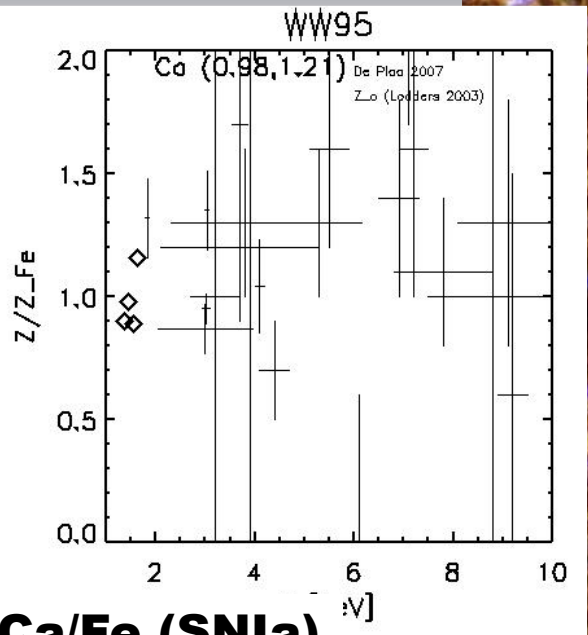
Fe



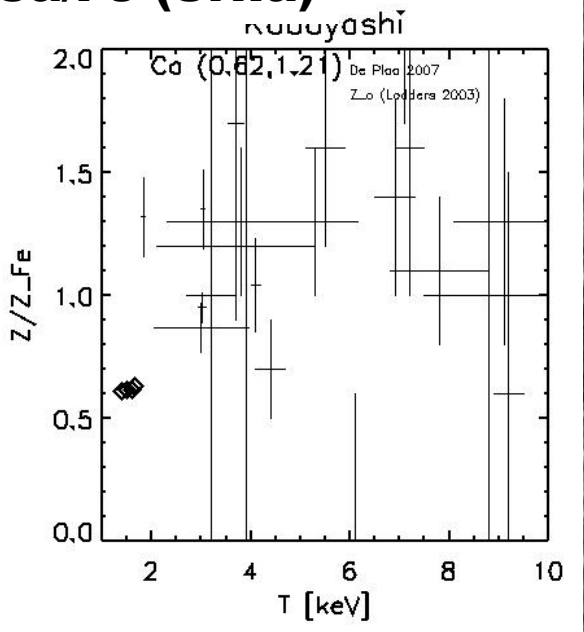


O/Fe (SNII)





Ca/Fe (SNIa)



MAGNETICUM

Conclusions

1) ICM: Clusters well reproduced

pressure profiles, SZ powerspectrum, no tension with CMB cosmology ?

2) Black holes: Observations well reproduced

Mass functions, luminosity functions, correlation function

3) Galaxies: Morphological Classification

Mass functions, angular momentum, relation to local environment

What is next ?

1) Coupling to mollecular network

(e.g. U. Maio), pressure driven strar-formtion, dust, ...

2) Finetuning stellar evolution

(e.g. C, Scannapieco), yields, stellar lifetimes, binary fractions, ...

3) Do Local Universe

(e.g. CLUES), various observations available: Atomic Gas, Mollecular Gas, internal structure of galaxies (Virgo/Coma ellipticals), chemistry, ICM (Virgo, Coma, ...)