N-body modelling of galaxy mergers and the mergers "mass deficit"effect

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Formation and evolution

Three main stages

Scenario of galaxy formation

semimajor axis + eccentricicty evolution ⇒ fate of the SBHB

- MBH pairing is driven by dynamical friction acting on the host galaxies and bind in a binary if they reach a relative separation:

$$a_{BHB} \sim \frac{GM_{BHB}}{2\sigma^2} \sim 0.2 M_{BHB,6}\sigma_{100}^{-2} \ \mathrm{pc}$$

control parameters: mass ratio q, gas fraction, redshift z of the merger.

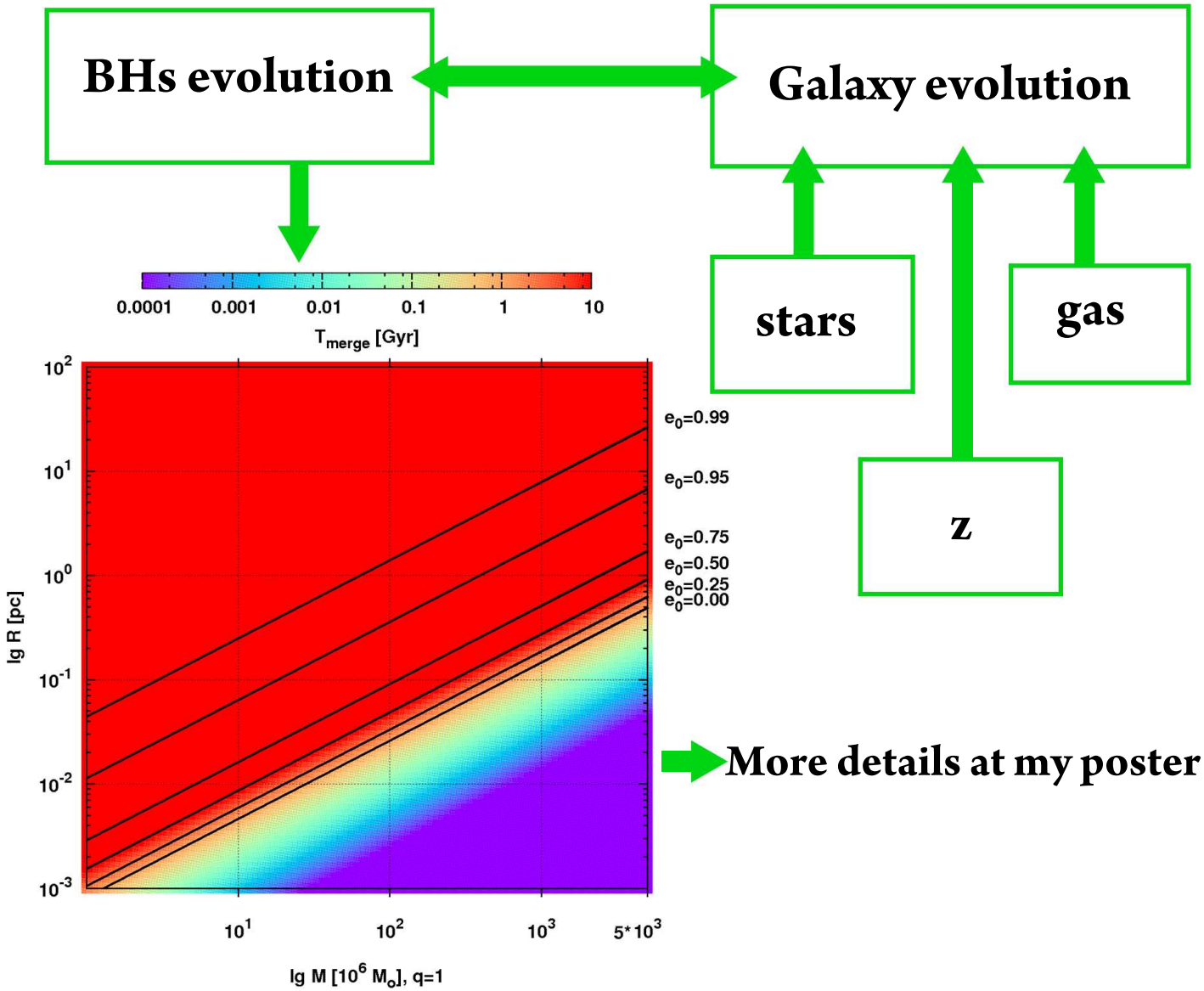
- Long-life as the binding binary system of the SBH.
- In less than an Hubble time, the two MBHs have to reach a separation:

$$a_{GW} \approx 2 \times 10^{-3} f(e)^{1/4} \frac{q^{1/4}}{(1+q)^{1/2}} \left(\frac{M_{BHB}}{10^6 M_\odot}\right) \ \mathrm{pc},$$

where $f(e) = [1 + (73/24)e^2 + (37/96)e^4](1 - e^2)^{-7/2}$ – function of the binary eccentricity e. *control parameters: gas + stars.*

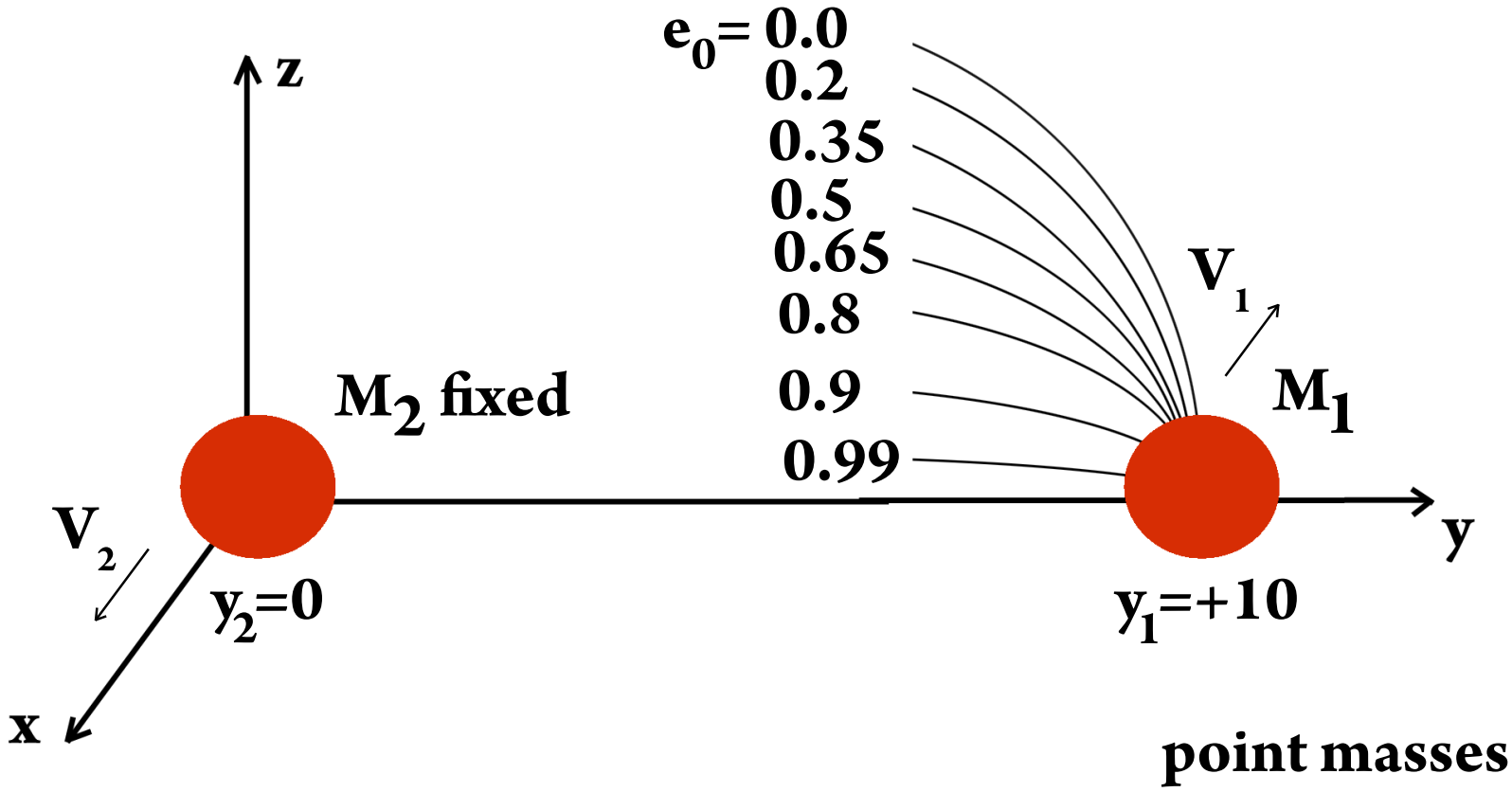
(common idea Begelman et al. 1980)

Scheme of linked evolution of BHs and galaxies



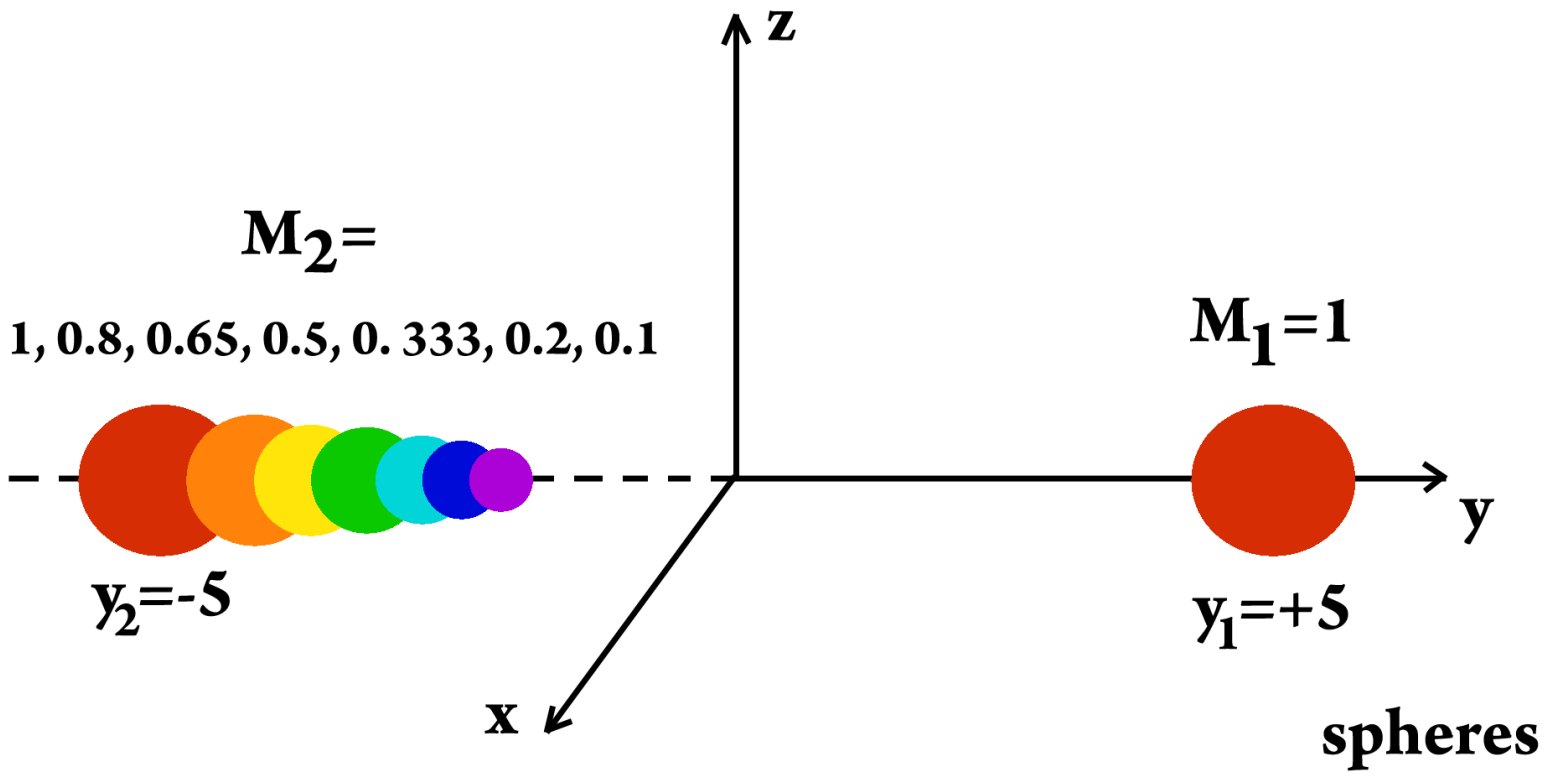
More details at my poster

Models

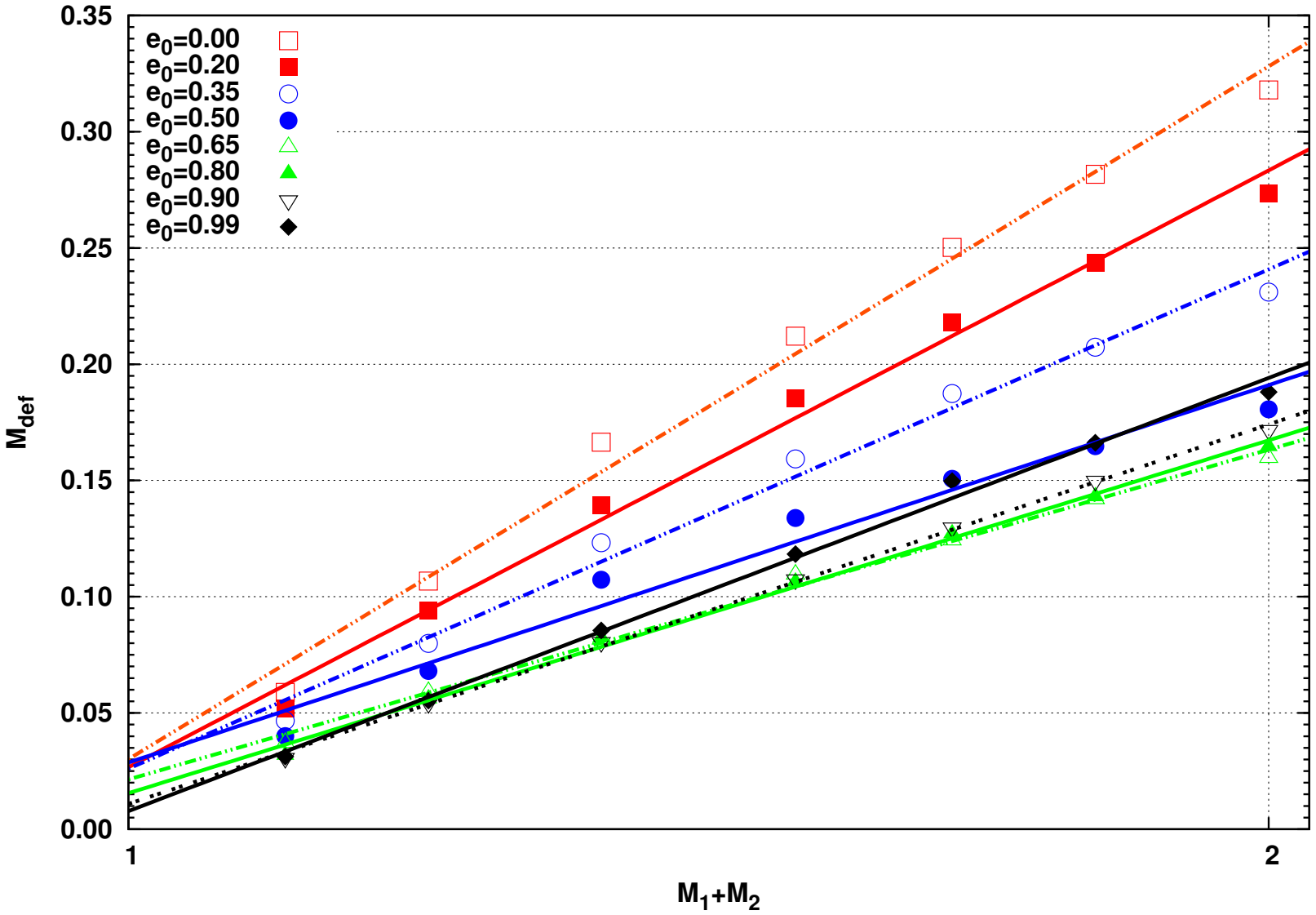

z
e_0= 0.0
0.2
0.35
0.5
0.65
0.8
0.9
0.99
V_1
M_1
M_2 fixed
V_2
y
y_2=0
y_1=+10
x
point masses

Models

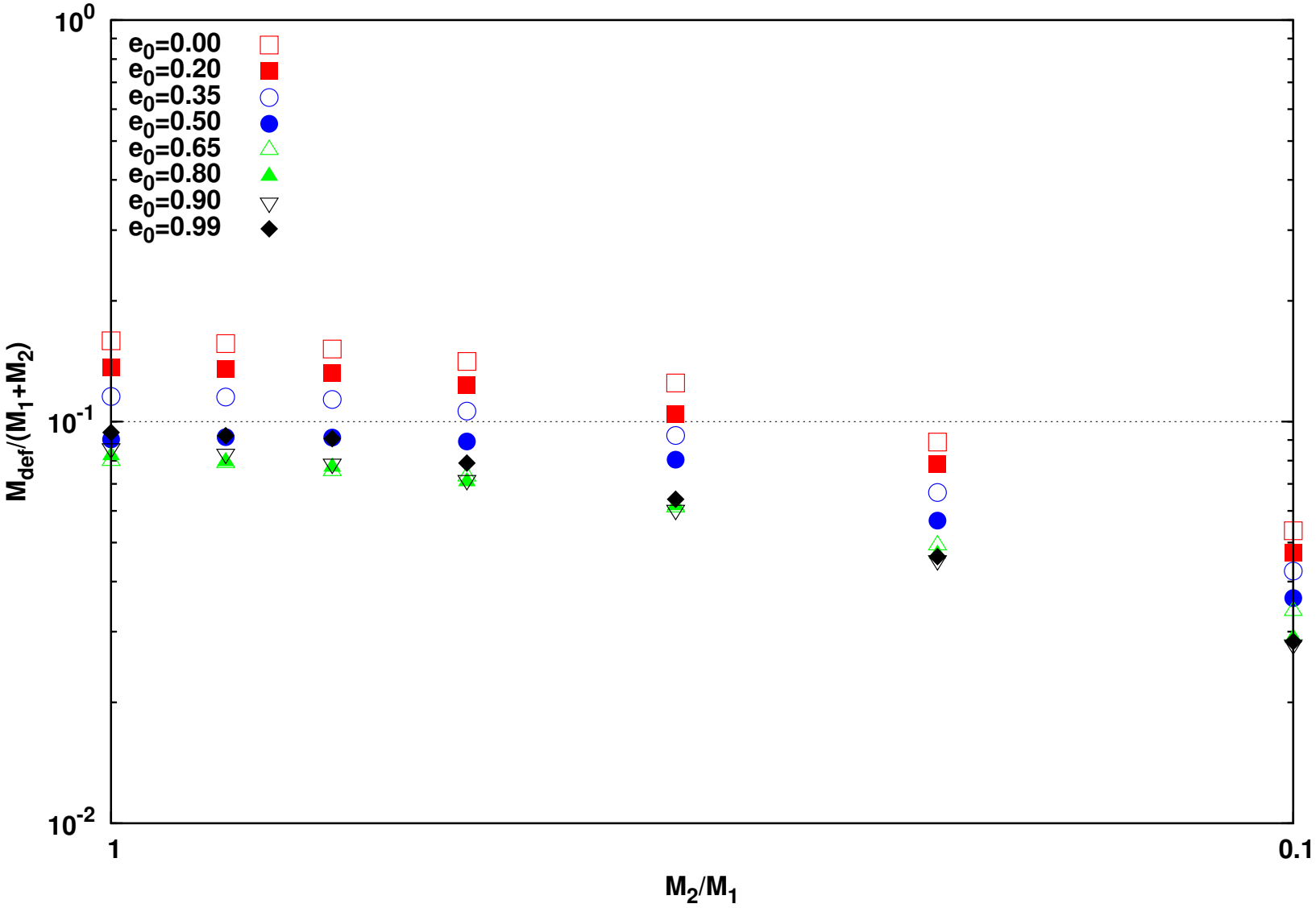
- the number of particles $N = 100k,\ 200k,\ 500k$
- Plummer-Kuzmin mass distribution
- $M_{def} = M_{tot} - M_1 - M_2$
- N-body TREE-GPU code



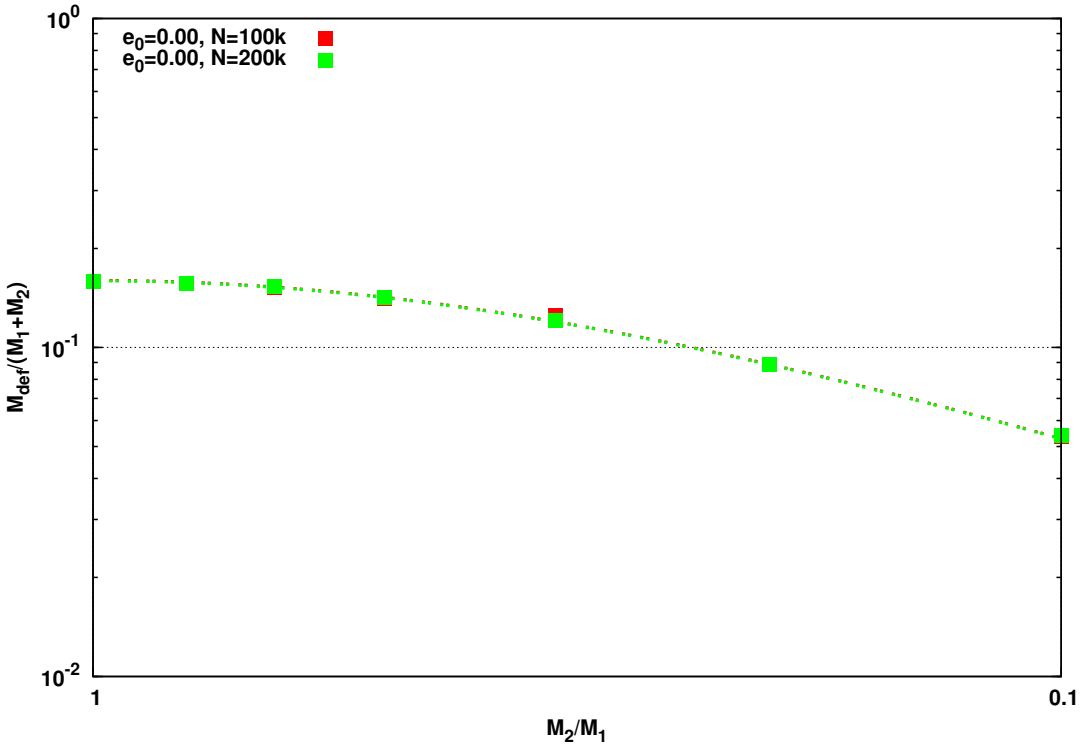
Results, N=100k



Results, N=100k



Results, N=100k, 200k

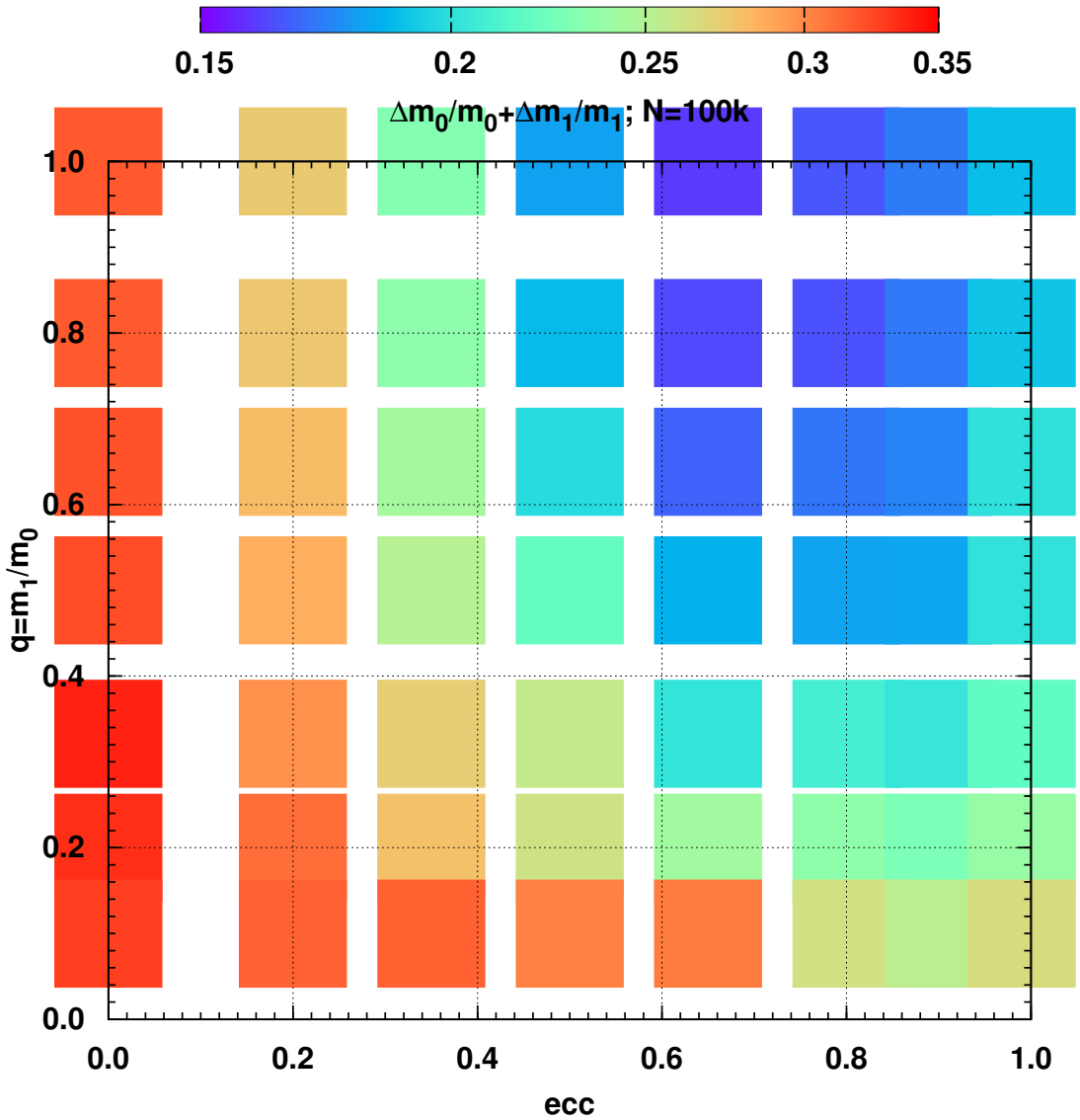


$$\frac{M_{def}}{M_{tot}} = \alpha \frac{q}{(1+q)^2}$$

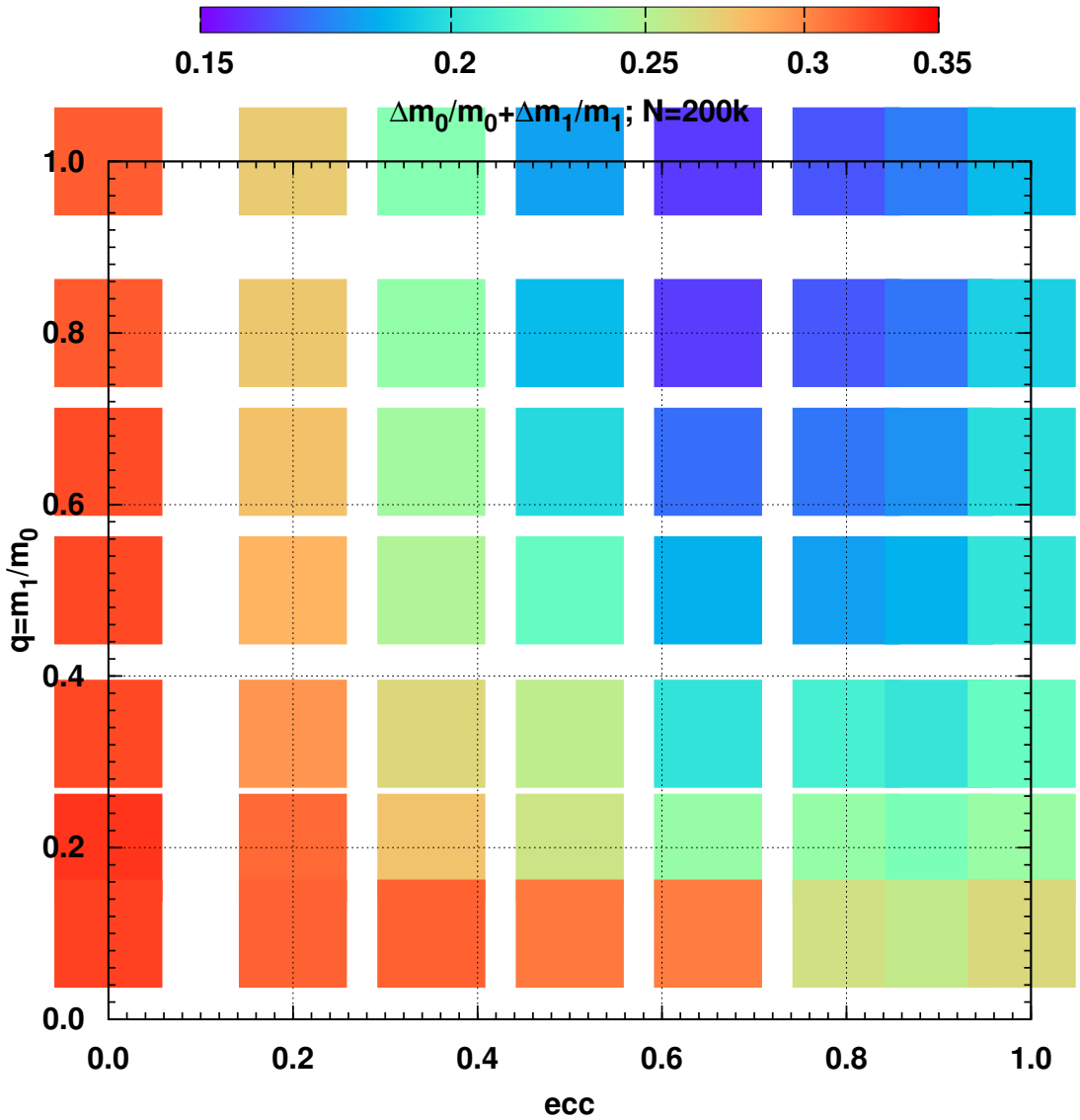
$N = 100k \;\; \alpha = 0.639612$

$N = 200k \;\; \alpha = 0.637817$

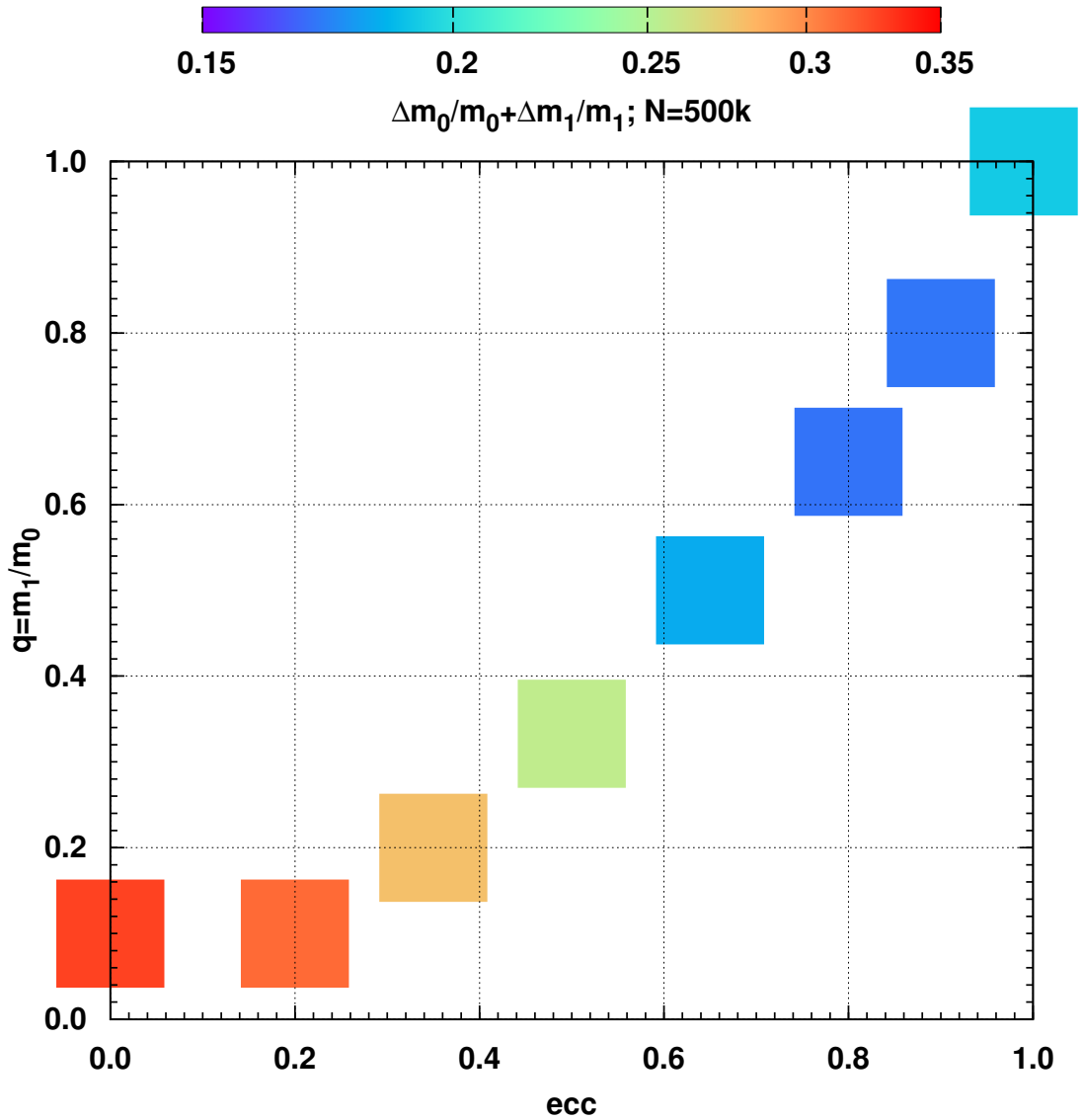
Results, N=100k



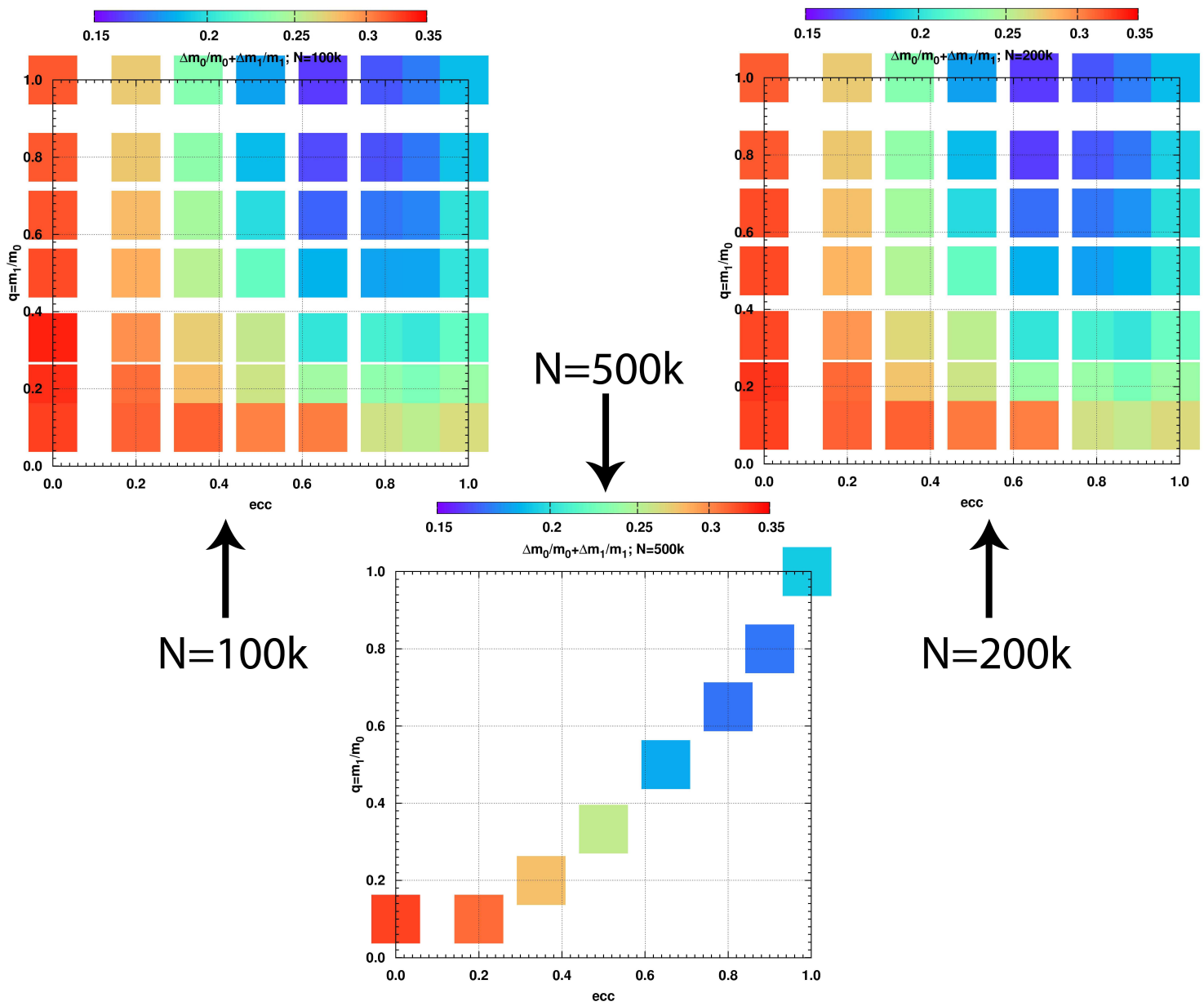
Results, N=200k



Results, N=500k



Results


0.15 0.2 0.25 0.3 0.35
Δm0/m0+Δm1/m1; N=100k
q=m1/m0
ecc
N=500k
Δm0/m0+Δm1/m1; N=500k
N=100k
0.15 0.2 0.25 0.3 0.35
Δm0/m0+Δm1/m1; N=200k
q=m1/m0
ecc
N=200k

Conclusions

Preliminary results from "stars"

- $M_{def} \sim M_{total}$
- $M_{def} \sim q$ a weak dependence
- $\frac{M_{def}}{M_{tot}} = \alpha \frac{q}{(1+q)^2}$
- $q = const \rightarrow e \uparrow \rightarrow \frac{\Delta m_0}{m_0} + \frac{\Delta m_1}{m_1} \downarrow$
- $e = const \rightarrow q \uparrow \rightarrow \frac{\Delta m_0}{m_0} + \frac{\Delta m_1}{m_1} \downarrow$
- $M_{def} \sim N = 100k, 200k, 500k$ a very weak dependence