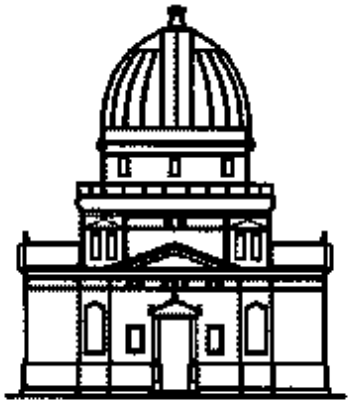
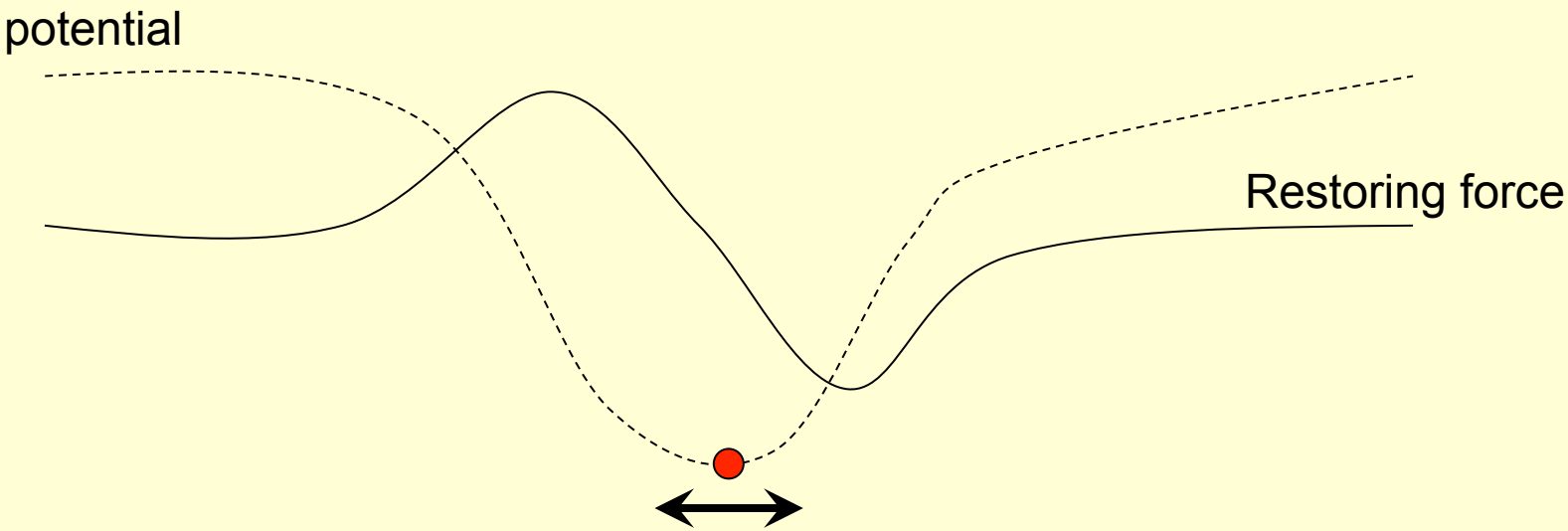
Predicting ‘analytically’ stripped and re-accreted mass fraction



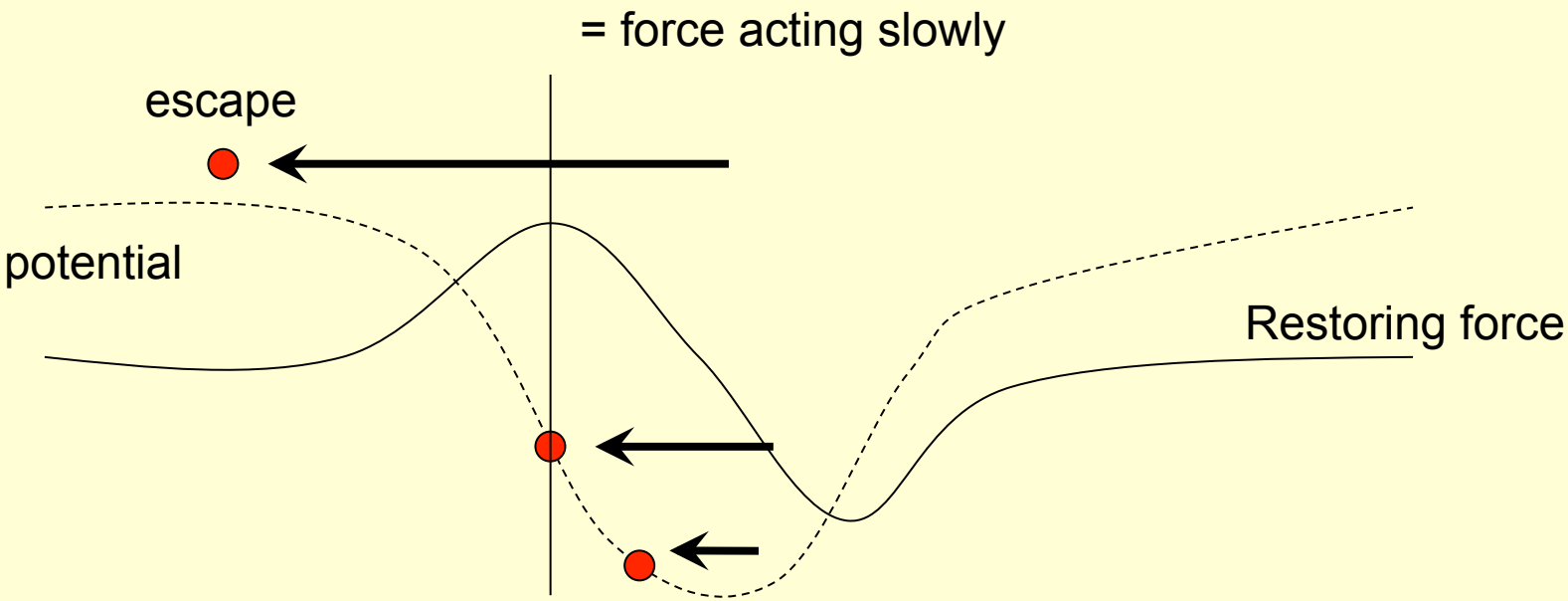
Observatoire astronomique de Strasbourg

Joachim Köppen

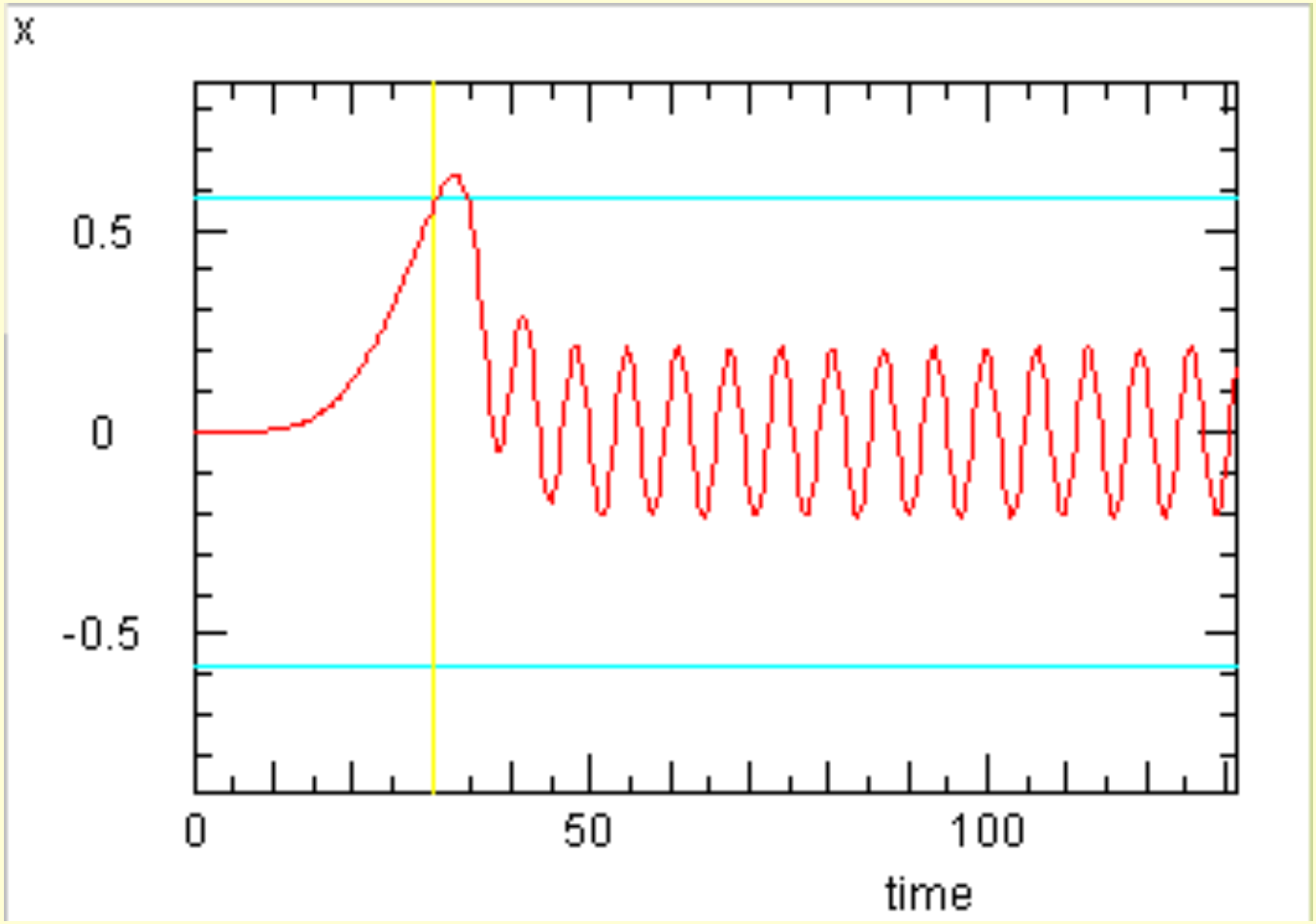
A gas parcel in the galactic disk



Gunn & Gott criterion



What happens after a short force pulse?



Taking RPS as a collision

- Momentum balance

$$\Sigma_{ISM} * v_{AFTER} = \Sigma_{ICM} * v_{ICM}$$

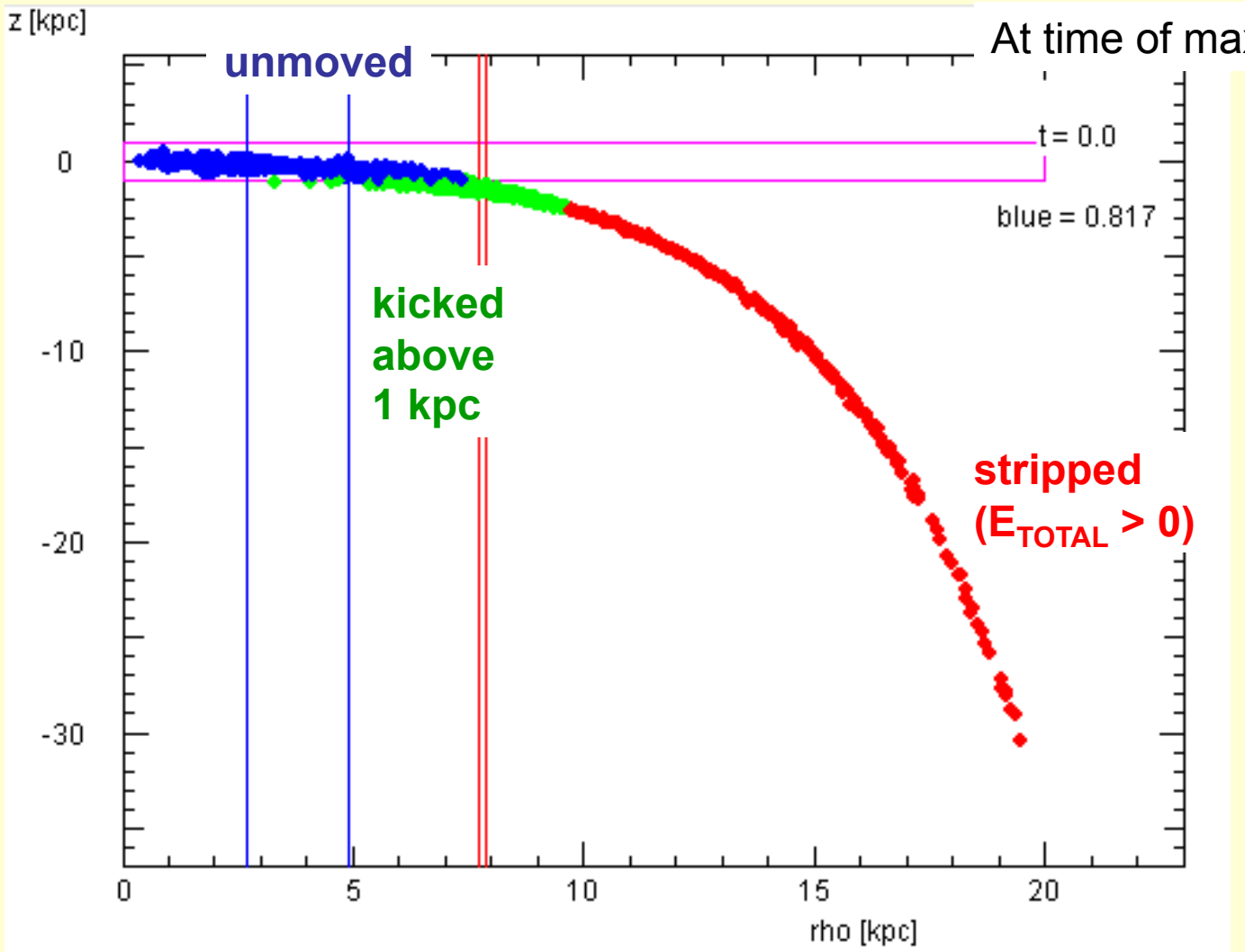
- Stripping if

$$v_{AFTER} > v_{ESC}$$

- Works well to explain stripped mass fractions in Pavel's SPH models

How to predict the re-accretable fraction?

Simulations with test particle models

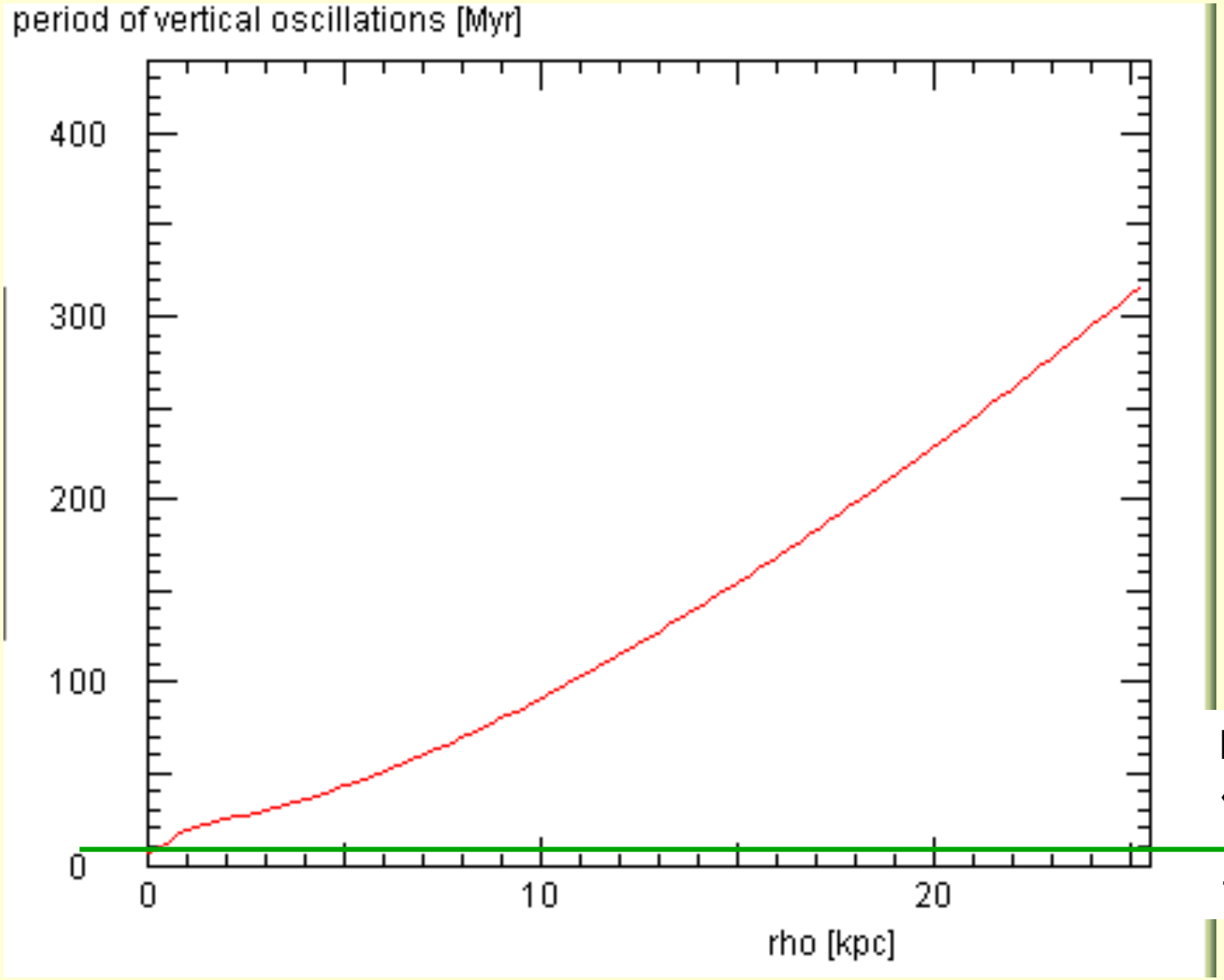


Remember the ballistic galvanometer?

- If an undamped harmonic oscillator is kicked by a pulse shorter than its natural period, it will oscillate with an amplitude which is proportional to the time-integrated force i.e. the momentum transferred to it.

NB: The amplitude is independent of the form of the pulse.

Period of vertical oscillations



Pavel's
« standard » run

10 Myr

Let's apply it to face-on RPS

- Equation of motion

  $d(\Sigma_{ISM} v)/dt = \rho_{ICM} (v_{ICM}-v)^2 - \Sigma_{ISM} d\Phi/dz$

- Solution: (a) during the kick ($z = v = 0$)

  $\Sigma_{ISM} v_{AFTER} = \rho_{ICM} v_{ICM}^2 \ \Delta t$

- Solution: (b) after the kick (Force=0; $v = v_{AFTER}$)

  $d(\Sigma_{ISM} v)/dt = - \Sigma_{ISM} d\Phi/dz$

  ➔ (harmonic) oscillation with amplitude corresponding to initial kick …

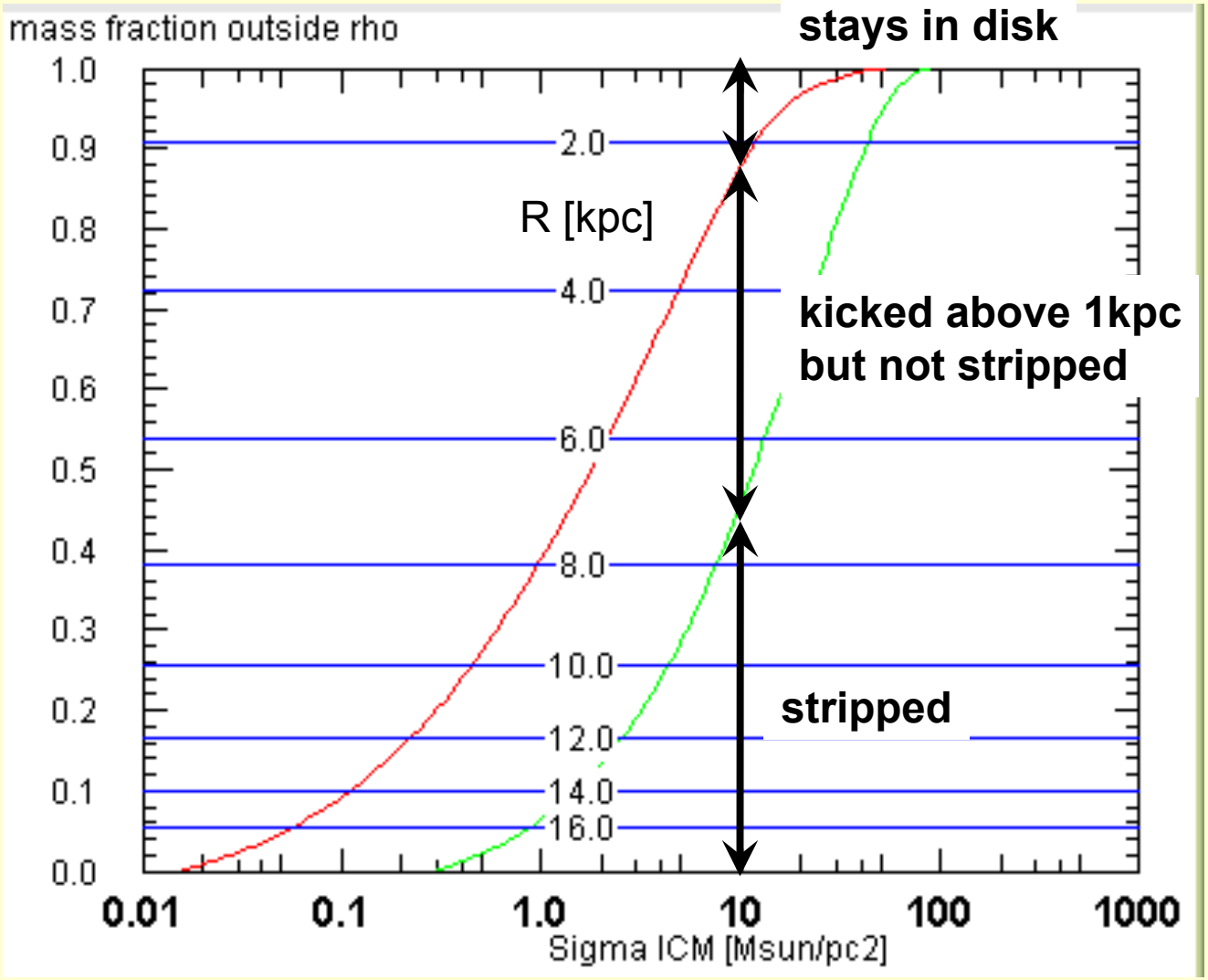
- the important parameter:

  $\rho_{ICM} v_{ICM}^2 \ \Delta t = v_{ICM} (\rho_{ICM} v_{ICM} \Delta t) = v_{ICM} \mathbf{\Sigma_{ICM}}$

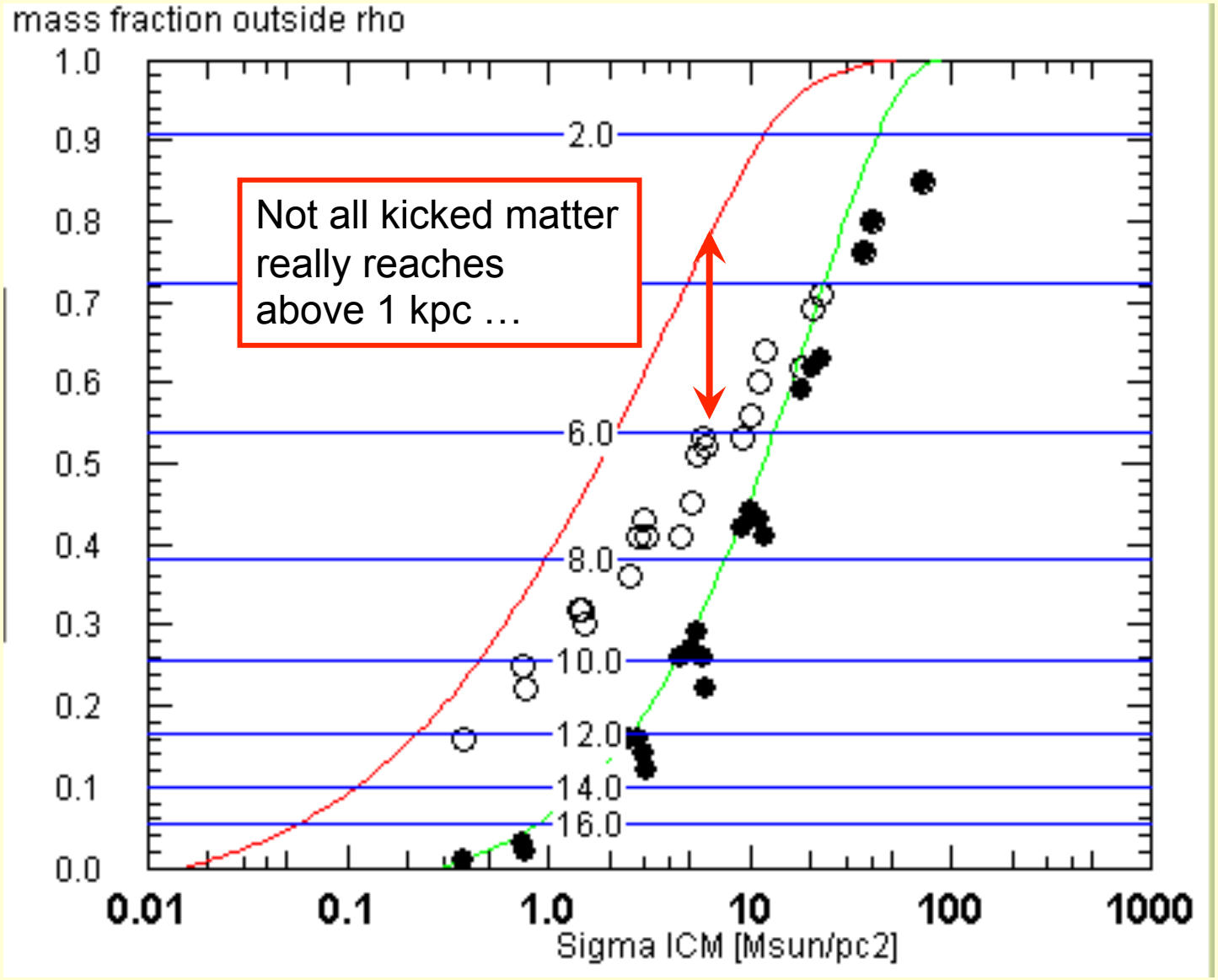
Given the speed after the kick

- … and the potential, we can compute how high above the disk the gas packet can move
- … and hence we can predict which parts of the disk will be displaced by some minimum height, say 1 kpc

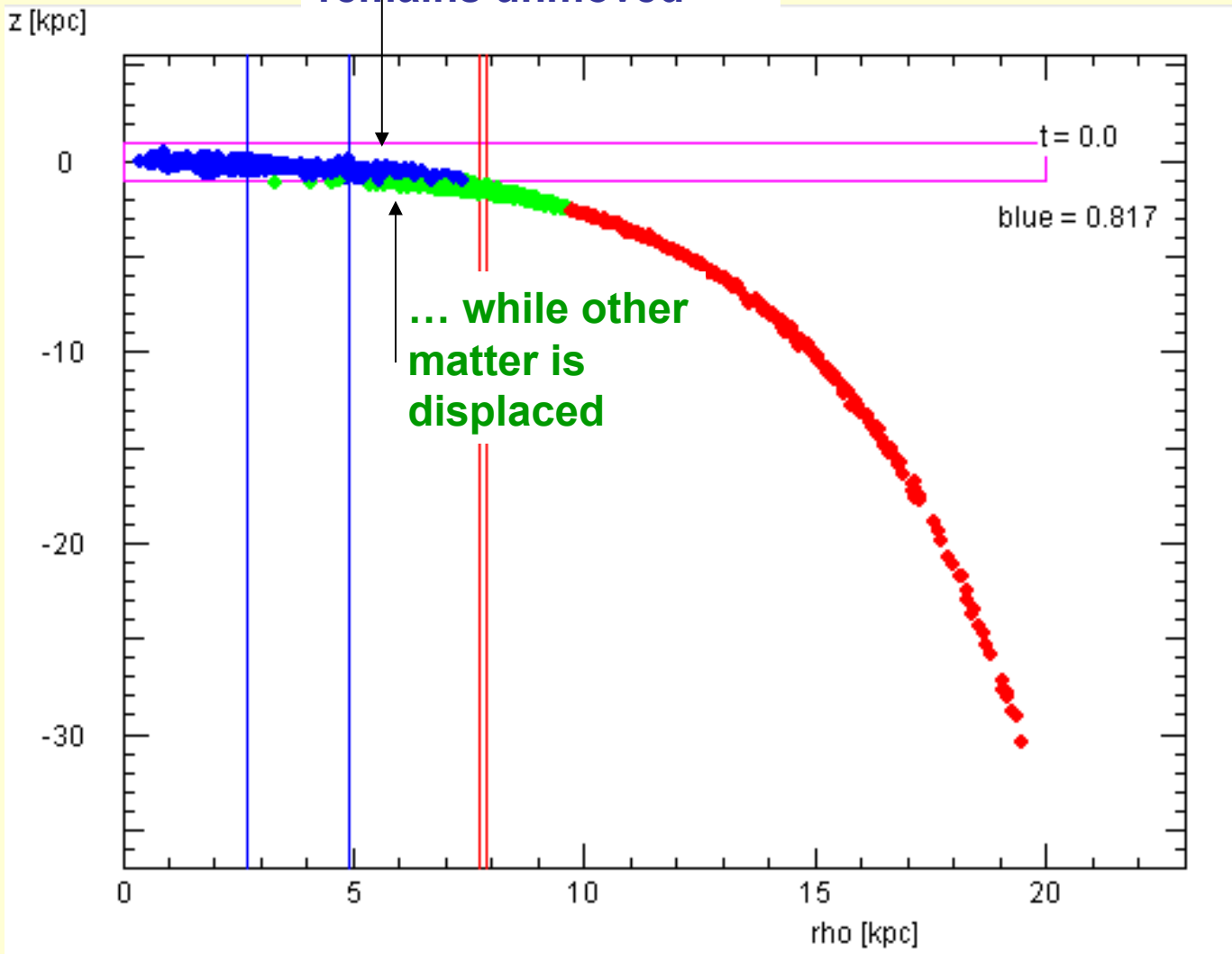
We get


mass fraction outside rho
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
R [kpc]
0.01
0.1
1.0
10
100
1000
Sigma ICM [Msun/pc2]
stays in disk
kicked above 1kpc
but not stripped
stripped

Compare with Pavel's SPH models



Depending on the initial vertical velocity some kicked matter remains unmoved



Summary

- Momentum transfer determines the fate of a gas parcel
- The primary parameter is the column density Σ_{ICM} of the accumulated ICM
- For the reaccreted fraction we can give only an upper limit
- For slow stripping, the efficiency of momentum transfer will be less!