Planetesimal formation by sweep-up coagulation

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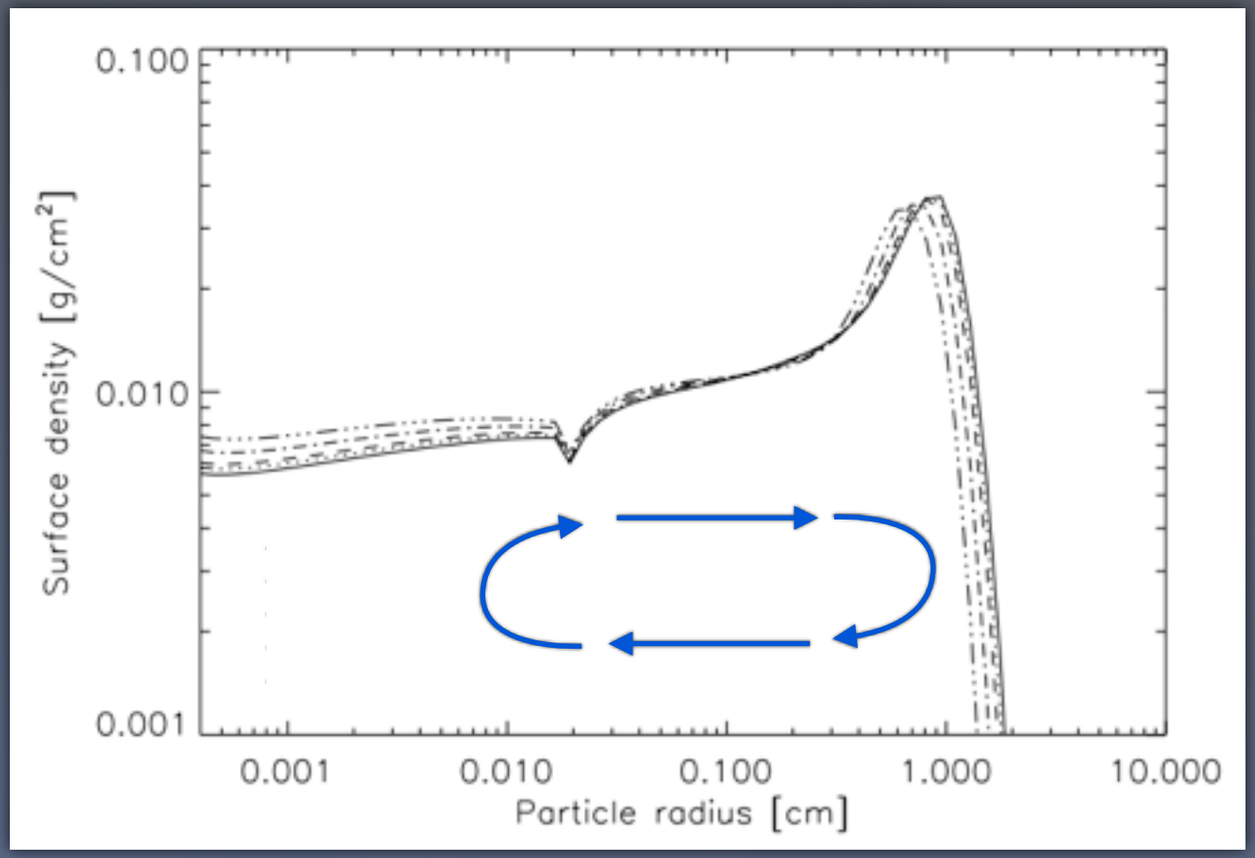
Outline

- Introduction
  - The collisional growth barriers
  - A new collision model
- Dust coagulation by sweep-up
  - Planetesimal formation by sweep-up
  - Velocity distributions and the formation of the first seeds
- Conclusions

The collisional growth barriers

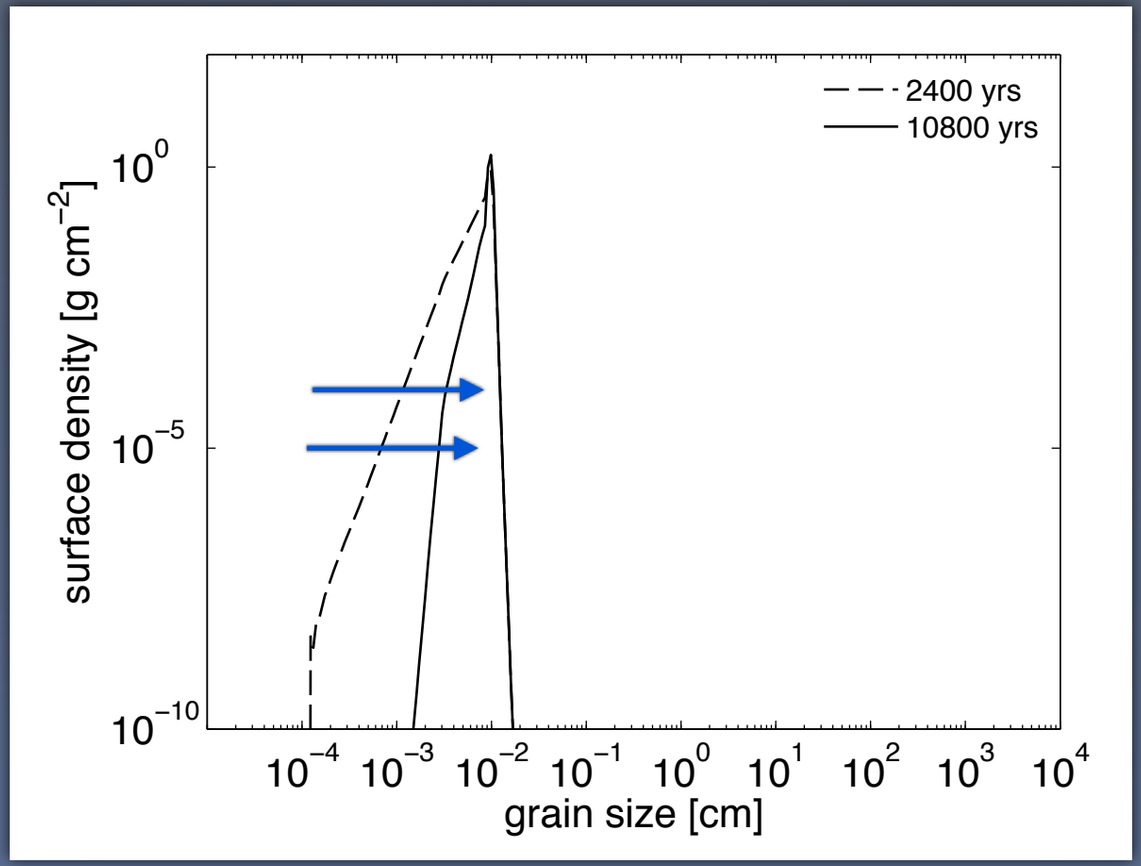


The fragmentation barrier

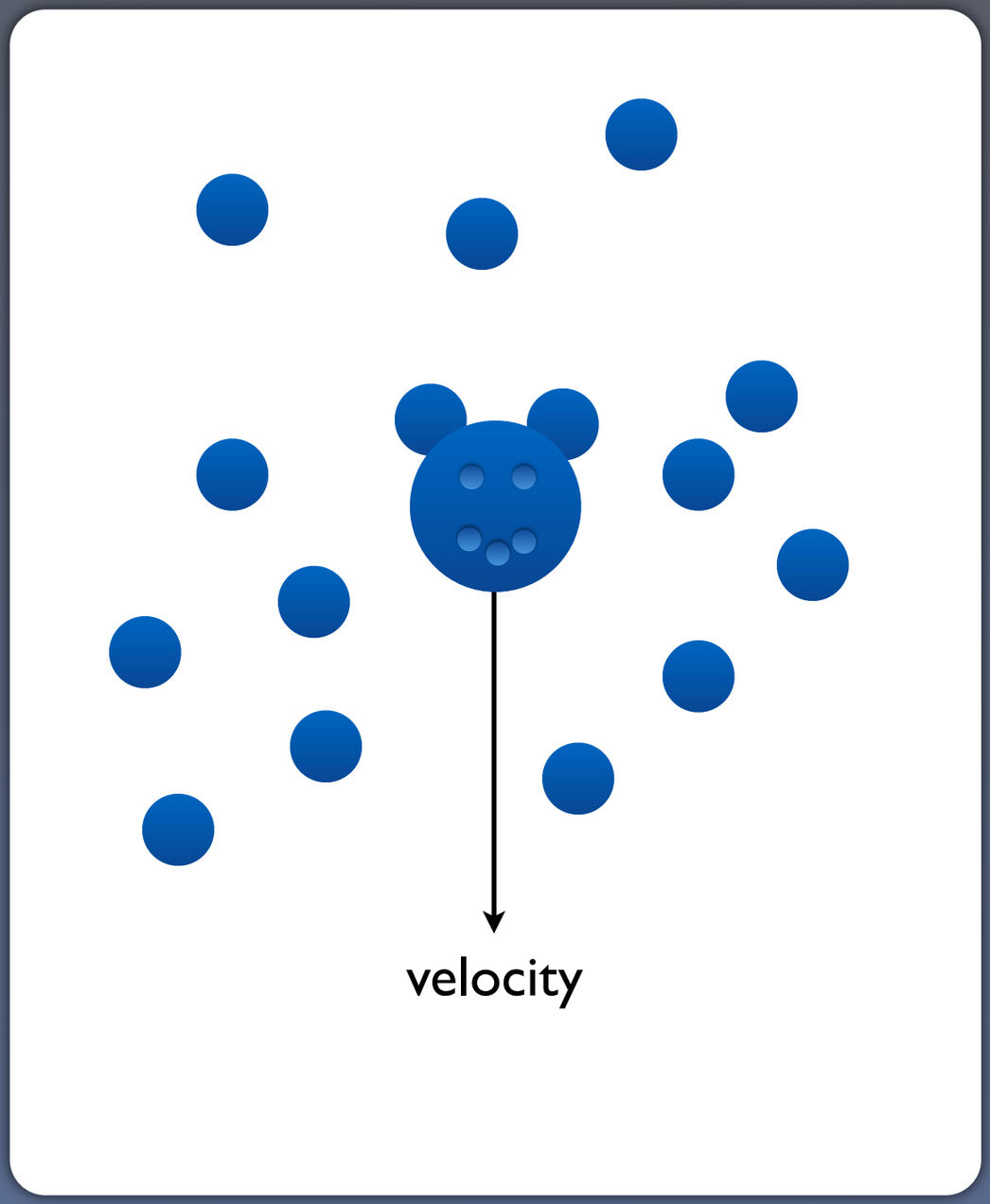
e.g. Brauer et al. (2008)

The bouncing barrier

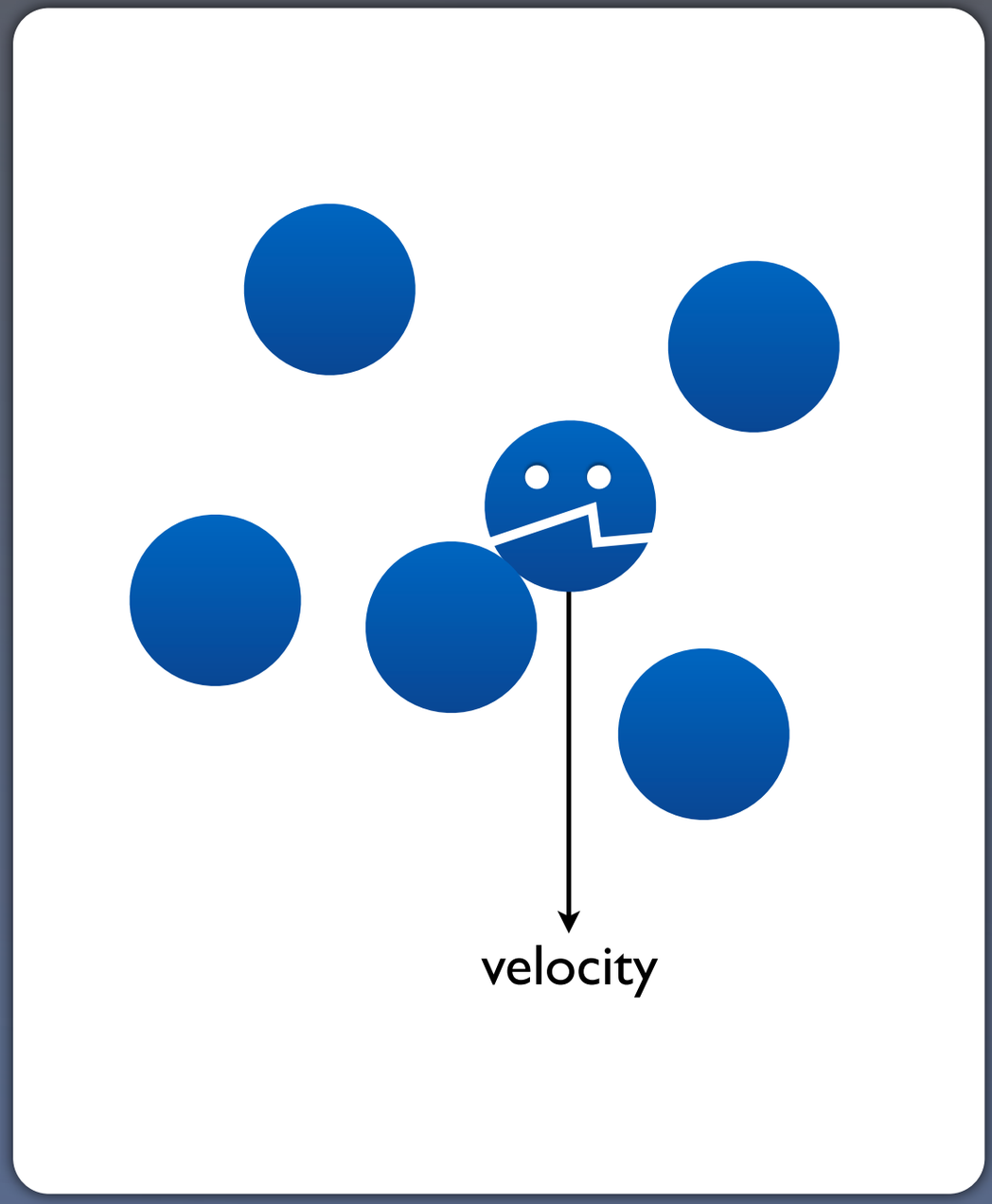
Güttler et al. (2010), Zsom et al. (2010), Windmark et al. (2012a)



A quick recap

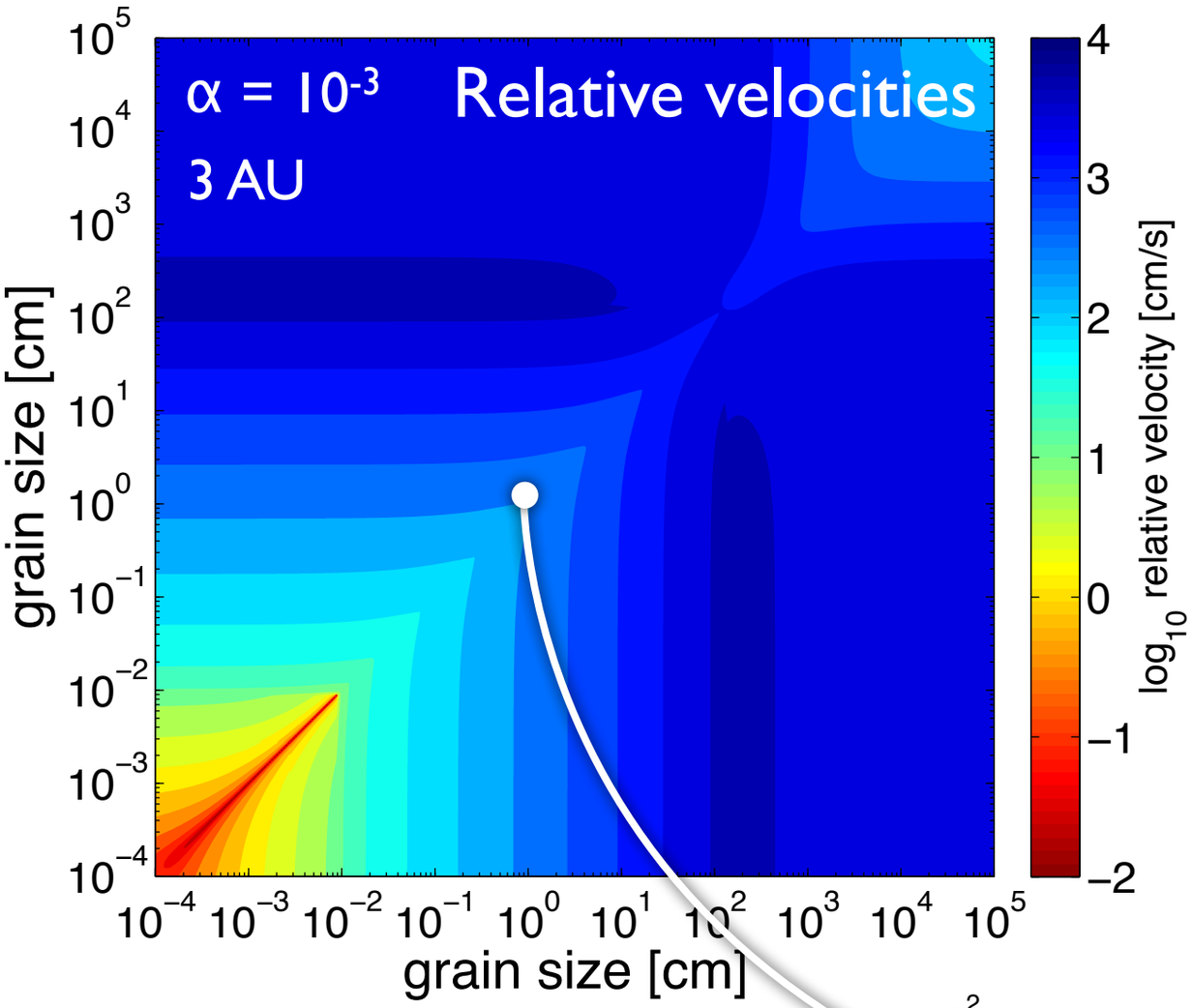


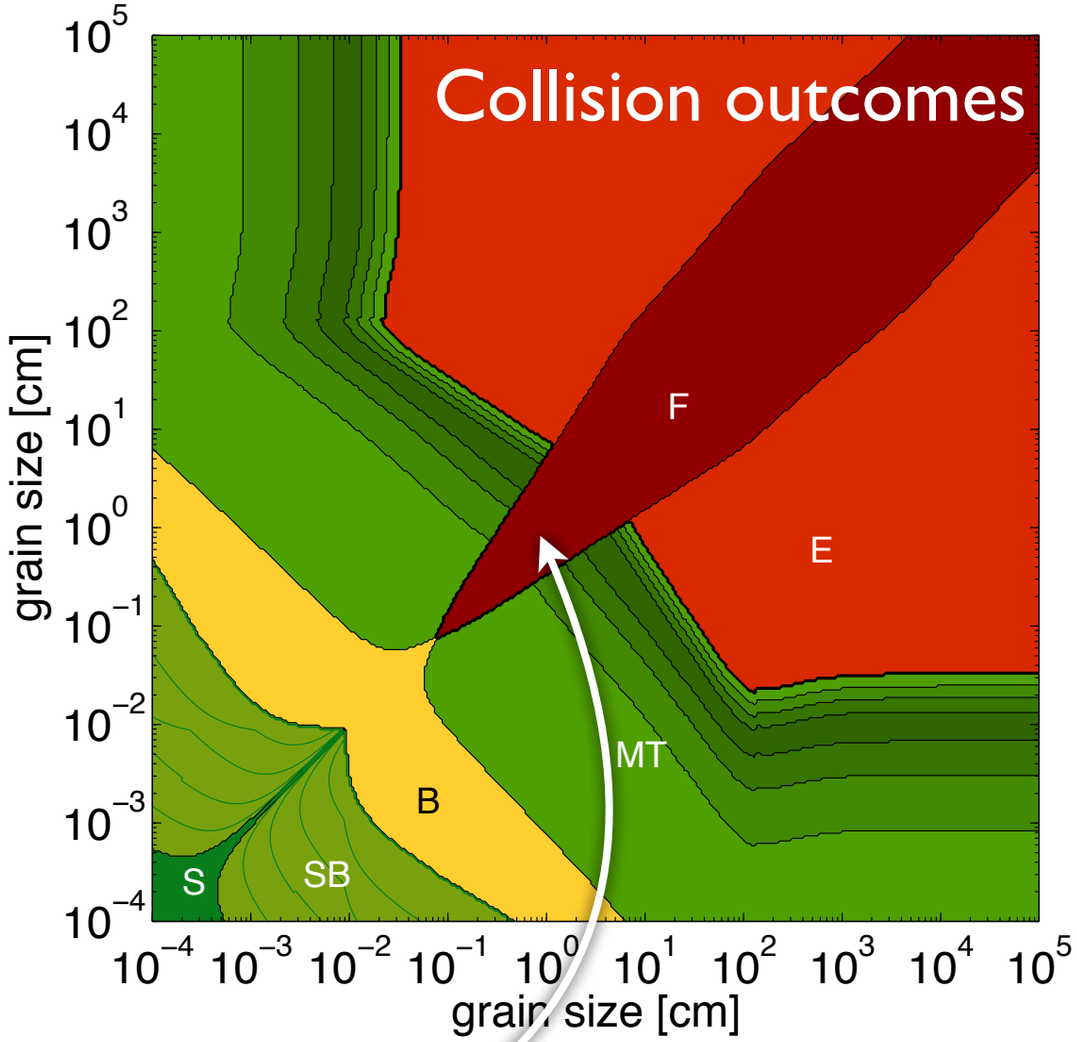
Good!

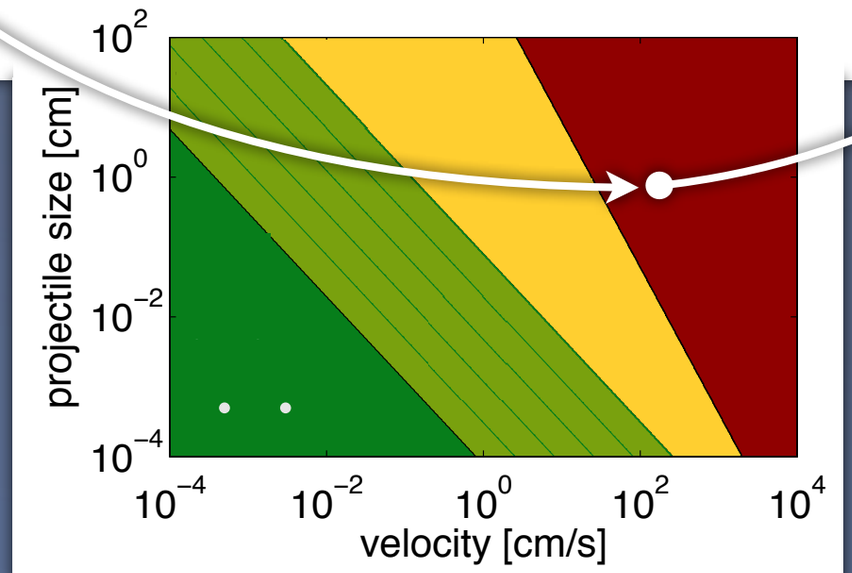


Bad!

A quick recap



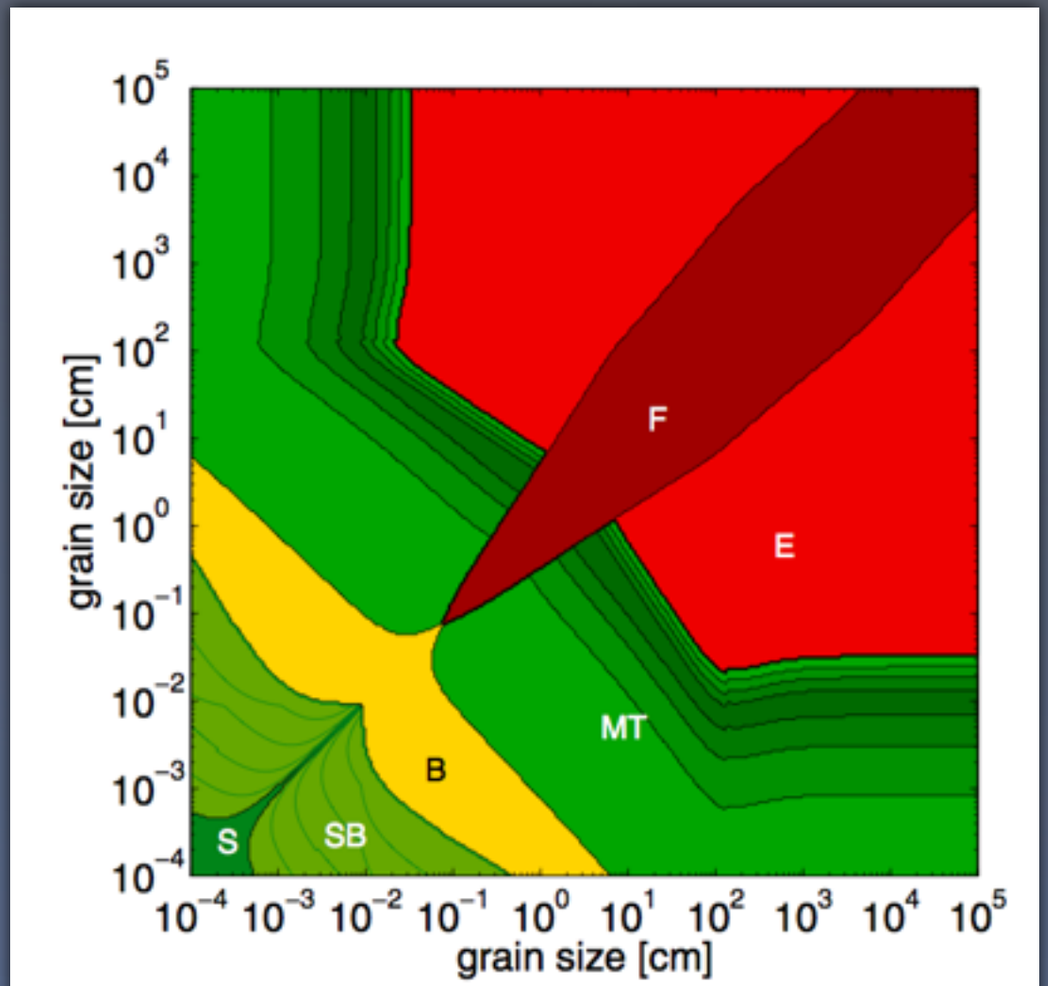


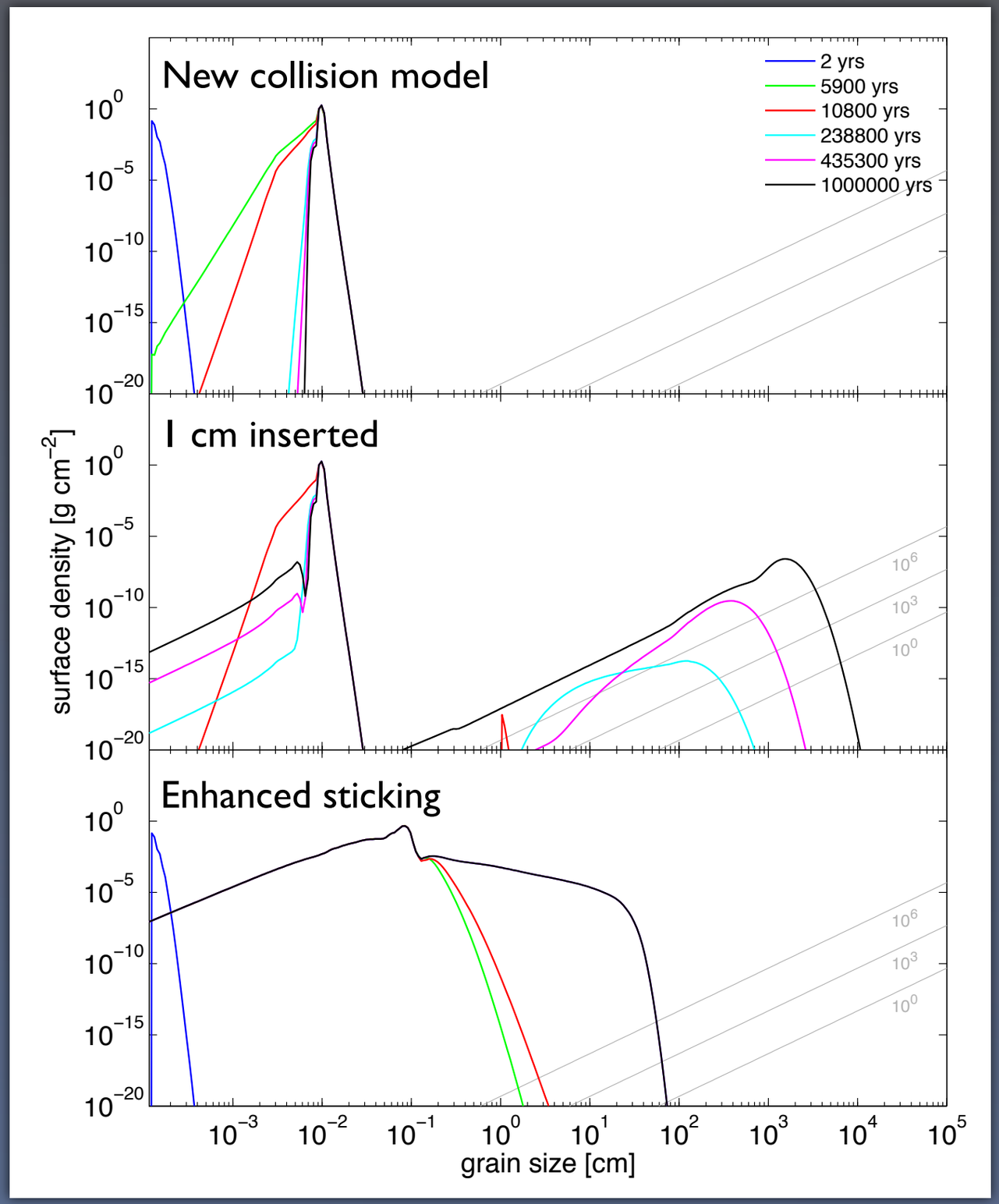


Largest grows
Largest unchanged
Largest erodes

Windmark et al. (2012a)

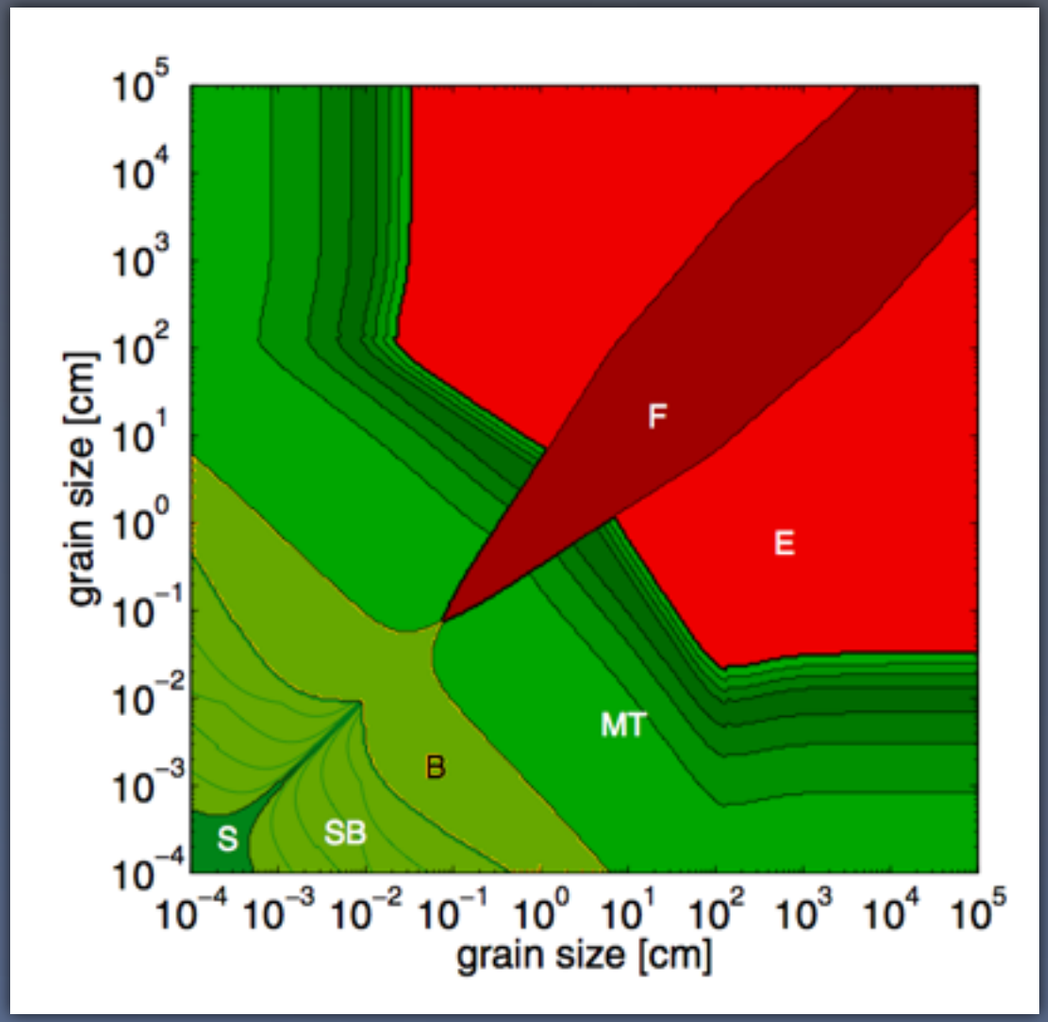
Local simulations at 3 AU

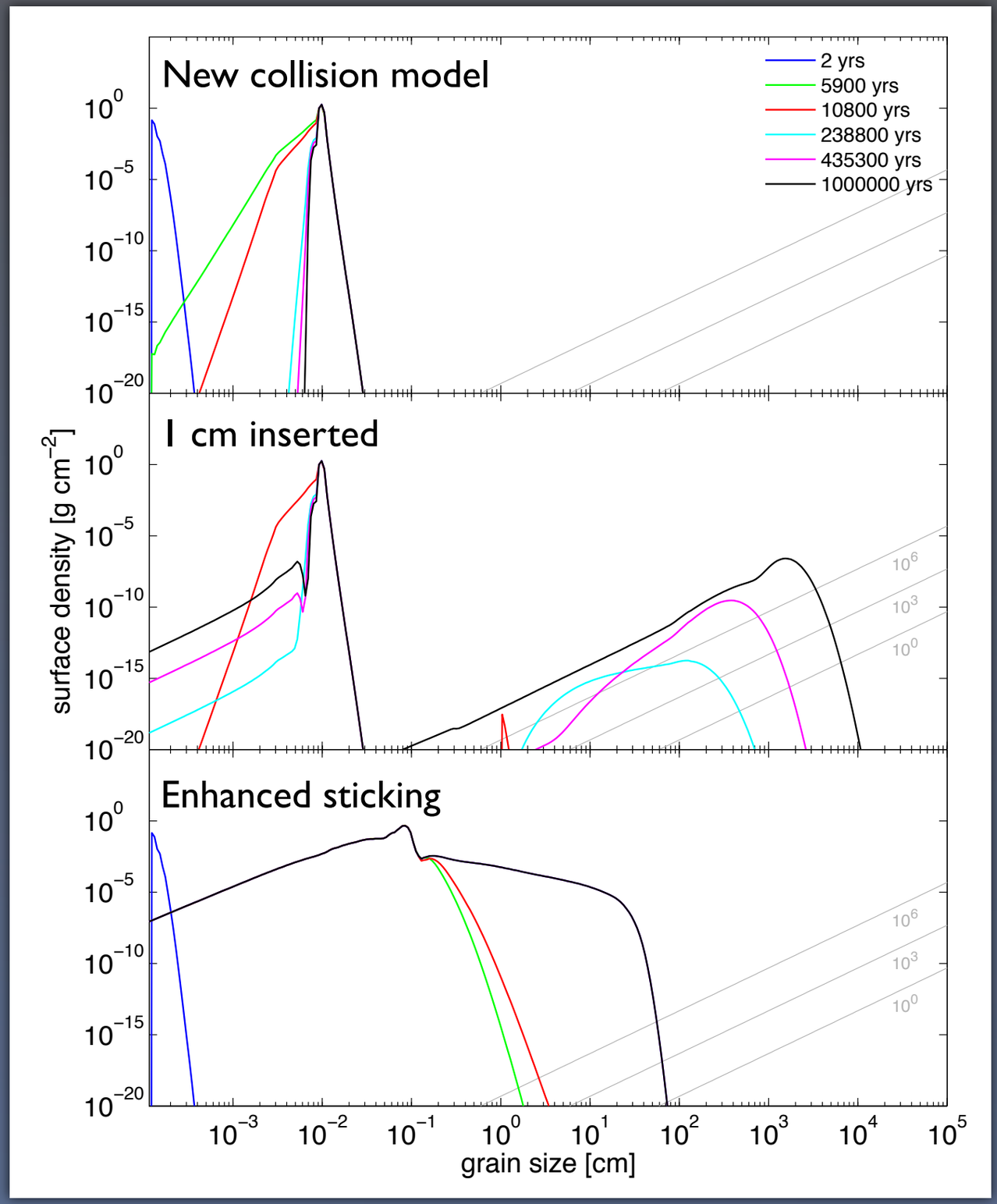




Windmark et al. (2012a)

Local simulations at 3 AU





Windmark et al. (2012a)

Growth timescales for sweep-up

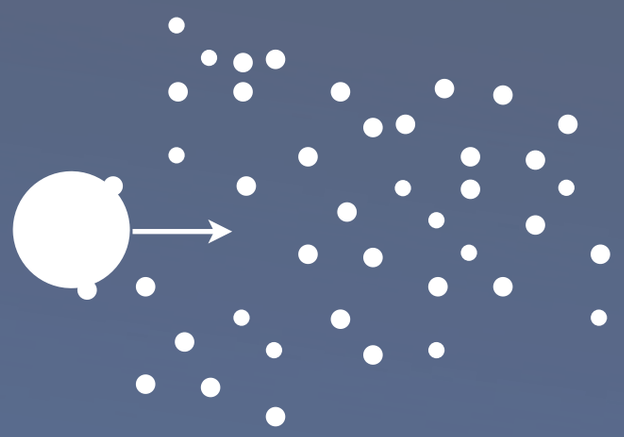
relative velocity

small particle mass density

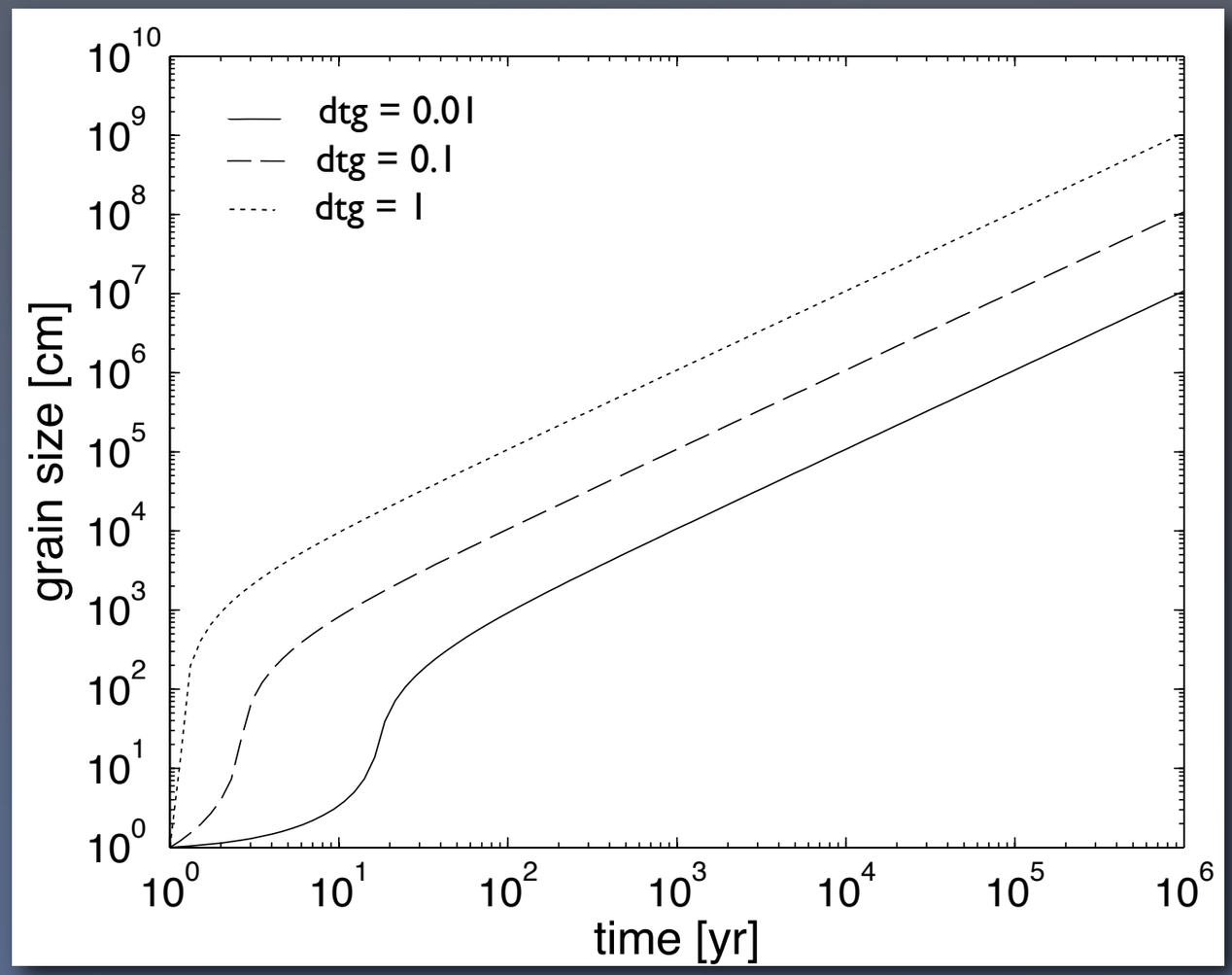
$$\frac{\mathrm{d}m}{\mathrm{d}t} = \sigma \Delta v \cdot \epsilon \rho_s$$

cross section

sweep-up efficiency



100 km reachable within 10^5 years

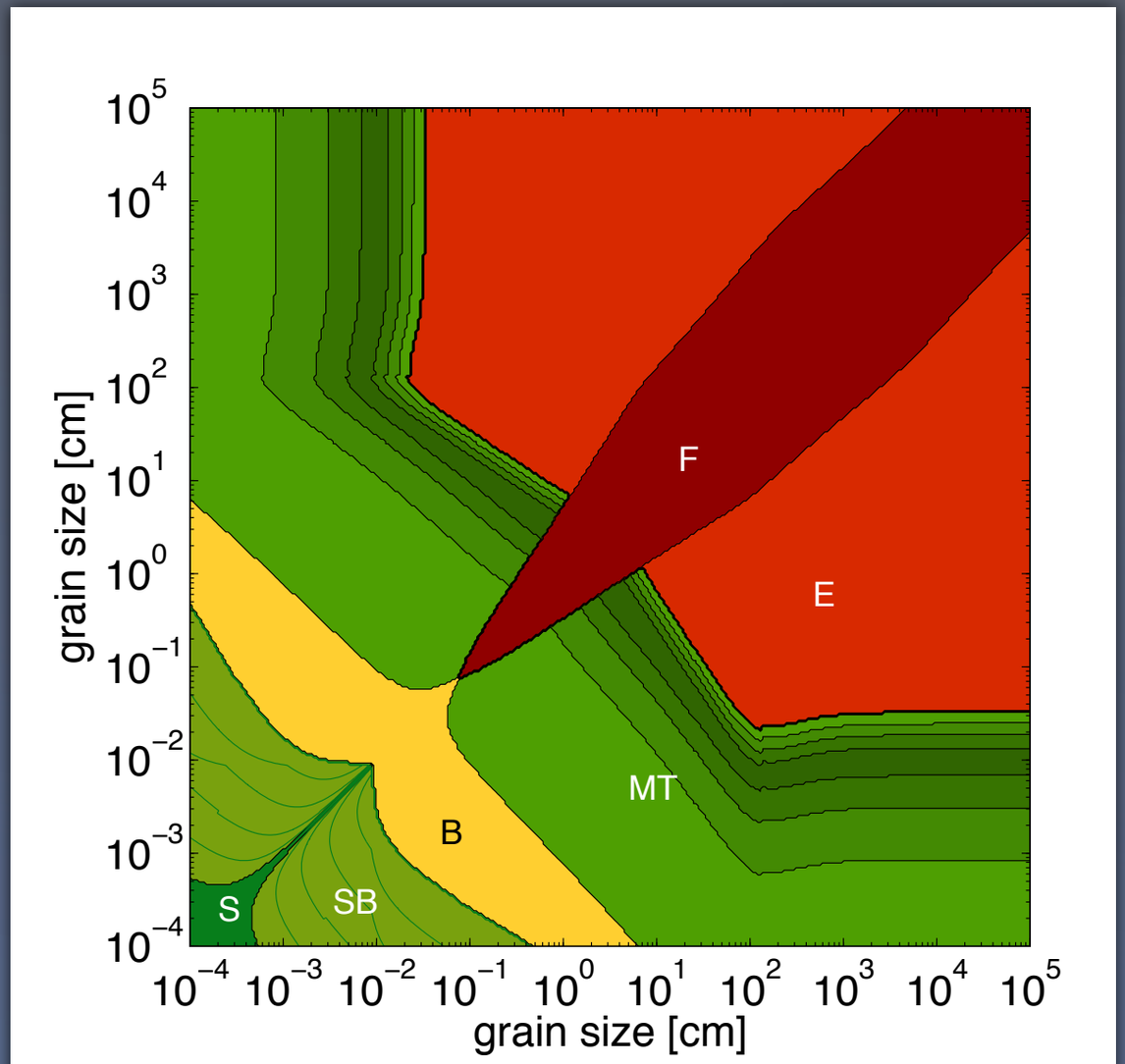


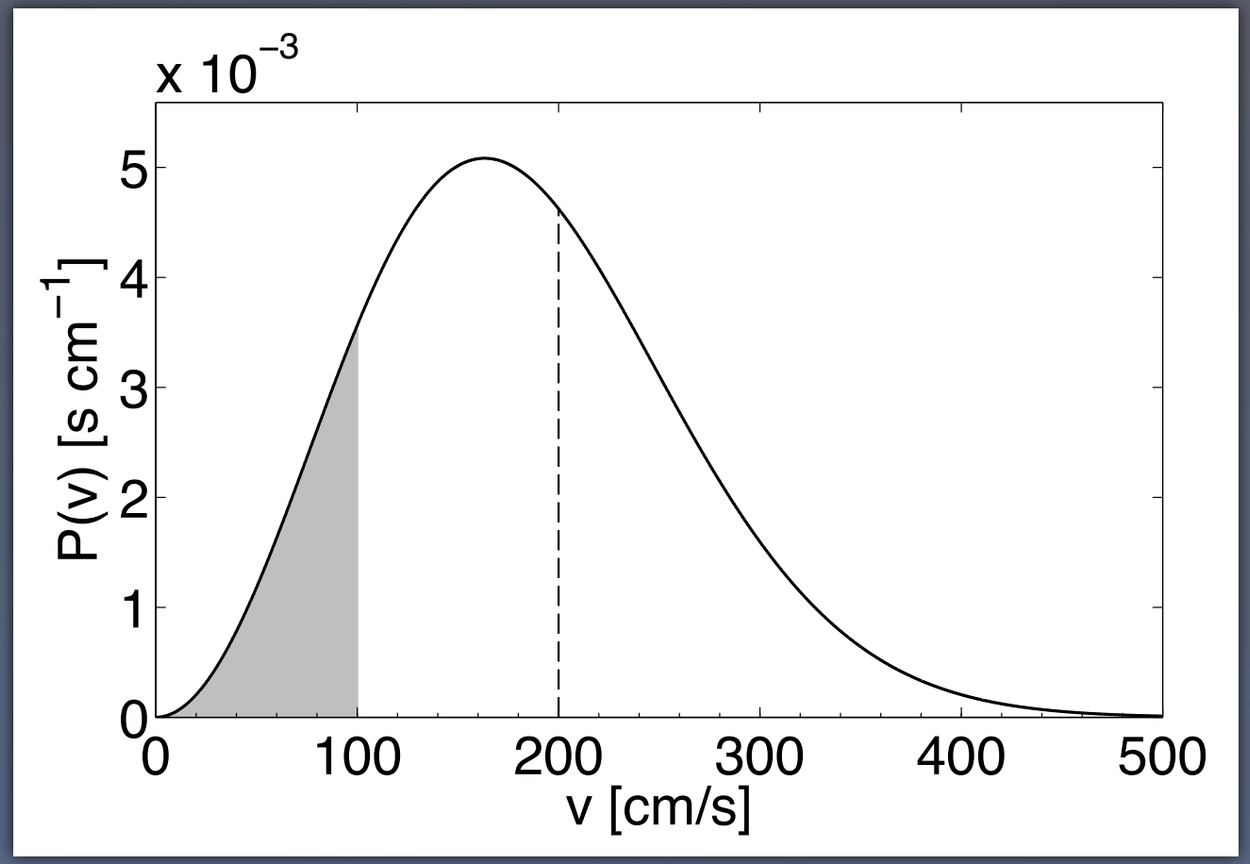
using Desch (2007) radial profile at 1 AU
assuming ε = 0.1

see also Johansen et al. (2008), Xie et al. (2010)

Adding a velocity distribution

Dust evolution simulations are usually based on the **mean** relative velocity...

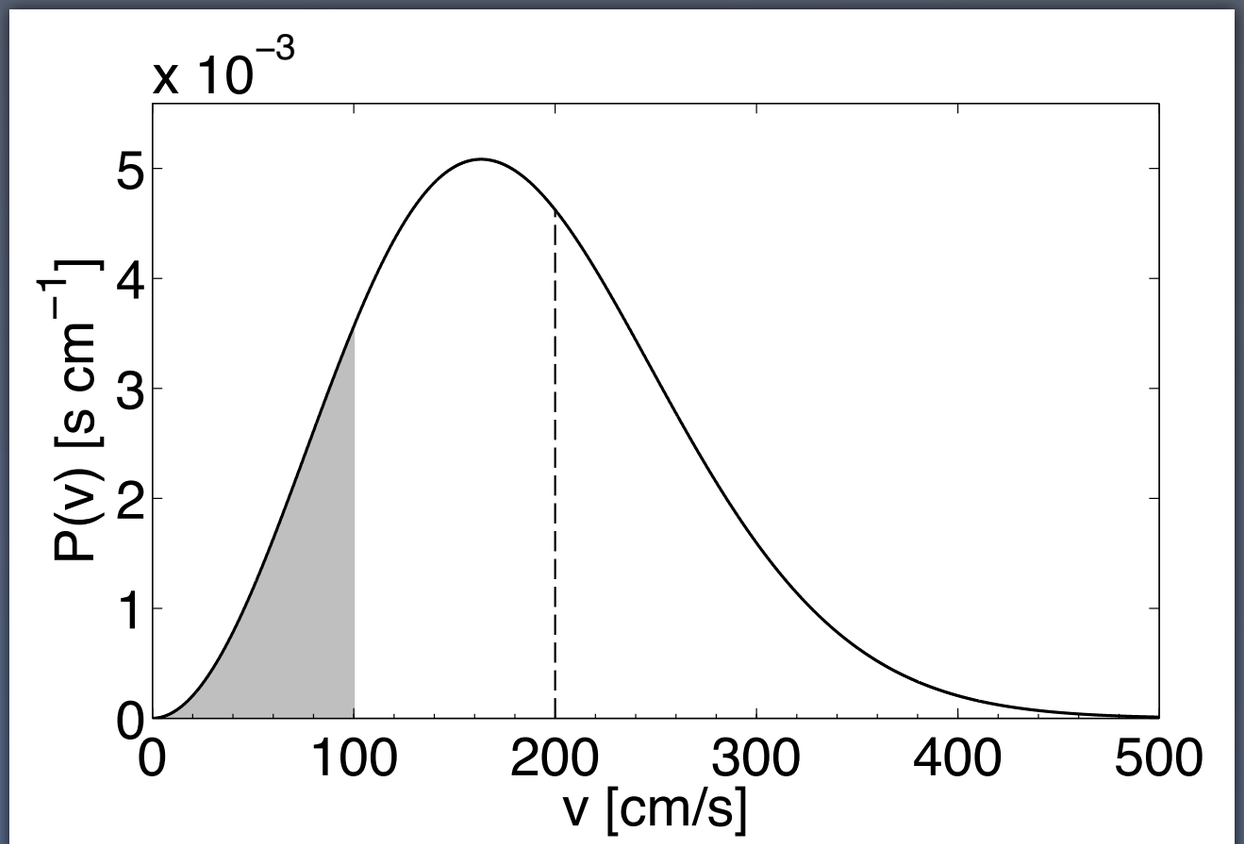




... but the addition of a collision velocity dispersion will smear out the barriers....

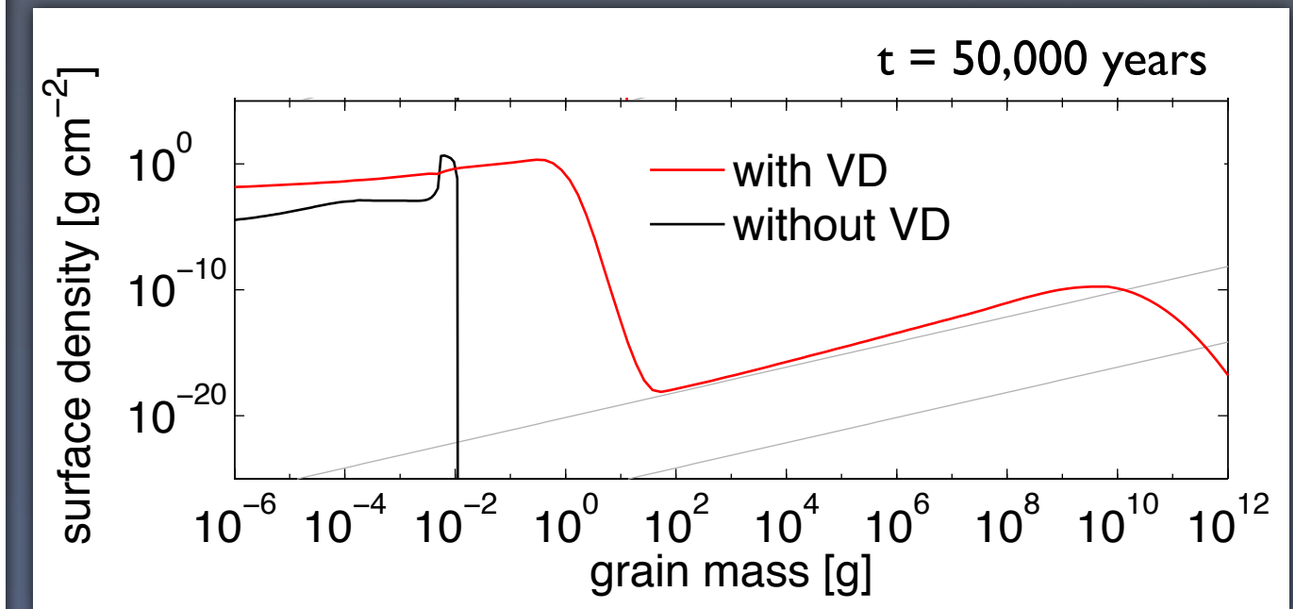
Windmark et al. (2012b)

Adding a velocity distribution



... but the addition of a collision velocity dispersion will smear out the barriers....

... so that growth can proceed to larger sizes.



Windmark et al. (2012b)

Conclusions

Even though the collision barriers prevents growth of the general dust population, a few **lucky particles** can **circumvent** the barriers.

Velocity distributions **smear out** the collision barriers, and naturally produce the first planetesimal seeds.