Sedimentation-driven coagulation inside the snow-line

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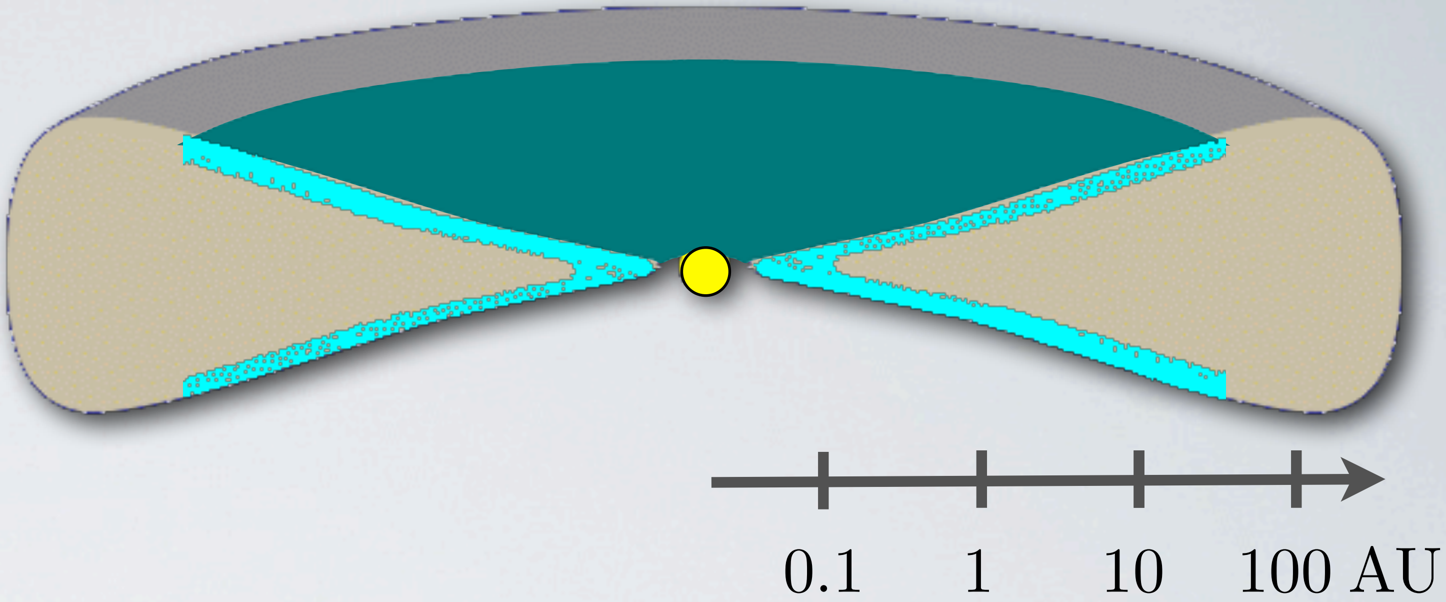
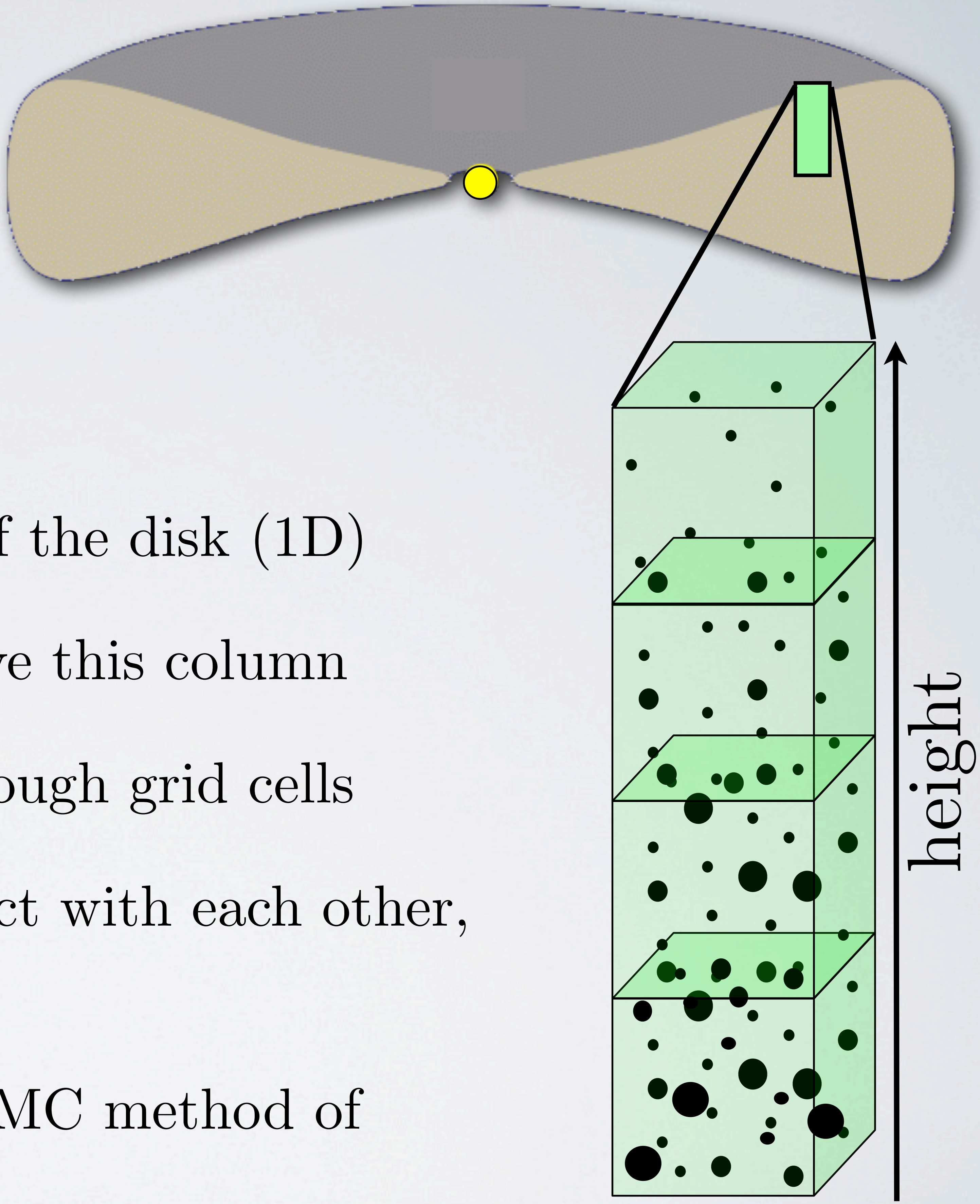
Our goal



- micron sized particles present in disk atmospheres for ~10^6 years (disk SED, 10 micron feature - Henning&Meeus, 2011)
- **<u>what prevents particle growth and settling to the midplane?</u>**
    - Brauer et al. 2008, Birnstiel et al. 2010: fragmentation produces micron sized particles, turbulence spreads the small particles vertically
    - Zsom et al. 2010: bouncing barrier prevents fragmentation, ***the question remains unanswered?***
        - local simulations performed at the midplane of the disk

Numerical set-up



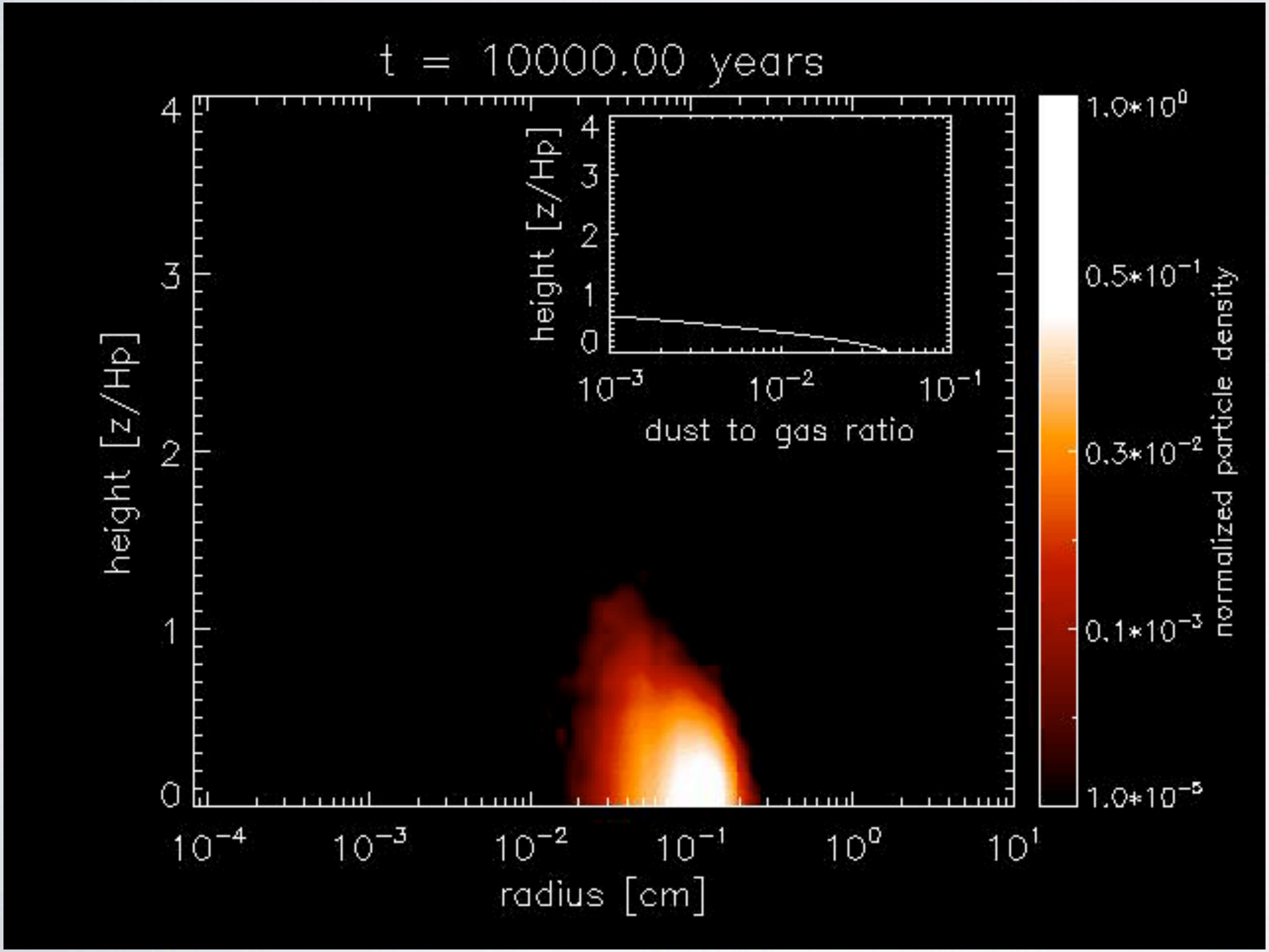
- simulate a vertical column of the disk (1D)
- particles do not enter or leave this column
- particles move vertically through grid cells
- Monte Carlo particles interact with each other, if located in the same grid
- Particle growth followed by MC method of Zsom&Dullemond, 2008

Physical processes

- Particle motion and relative velocity sources:
    - Brownian motion, turbulence (Ormel&Cuzzi relative velocity, Shakura & Sunyaev alpha description), vertical settling
- Particle growth:
    - Collision model based on laboratory measurements (Güttler et al. 2010)
    - includes sticking, bouncing, fragmentation
- Particle structure:
    - hit&stick porosity model of Okuzumi et al 2009

Results

- Shakura & Sunyaev **alpha** turbulence parameter is **10^{-4}**

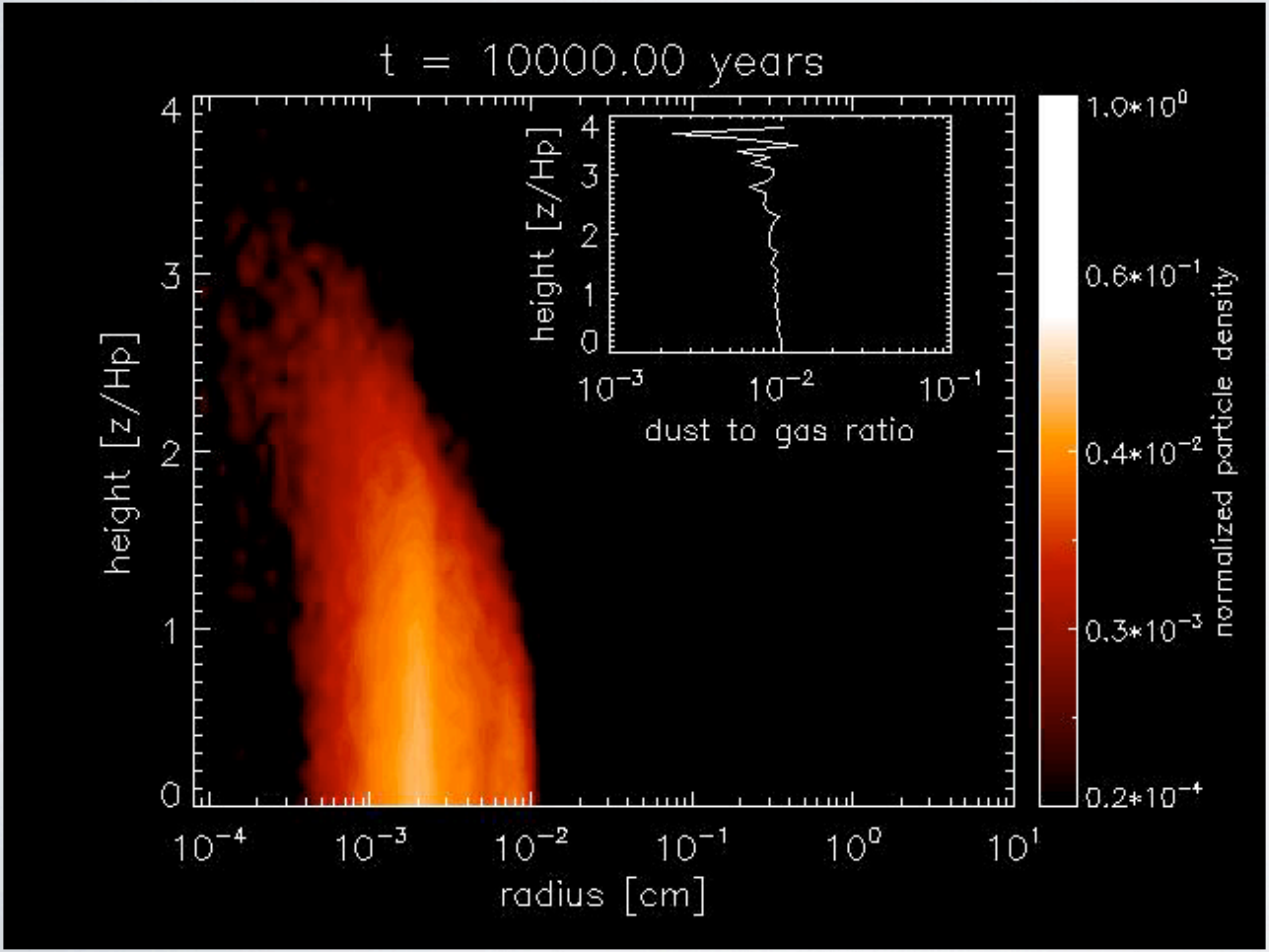


$H_d = 0.2\ H_g$

size: 10^{-1} cm

Results

- Shakura & Sunyaev **alpha** turbulence parameter is **10^{-2}**



$H_d = 0.95\ H_g$

size: 10^{-2} cm

Conclusions

- Local simulations: to study the effects of unexplored processes
    - but does not necessarily indicate global behavior
- Density in local simulations of Zsom et al 2010: *constant*
    - does not produce small particles for any alpha
- Density in 1D simulation: *decreasing function of height*
- ***This combined with high alpha produces small grains!***
- For more details see **Zsom et al, 2011, 534, 73**