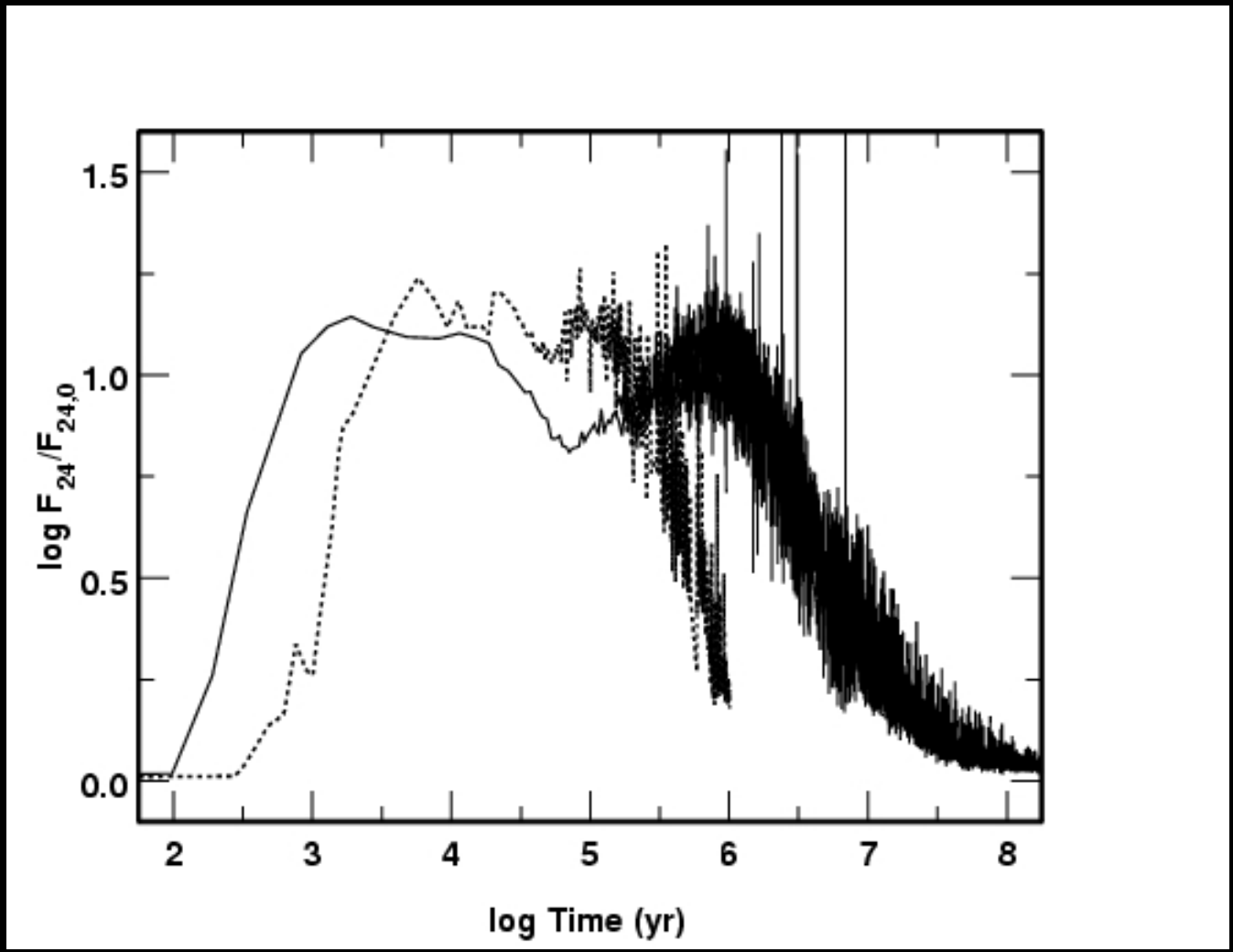
Disk Issues

- Evolution of gas
- Evolution of solids

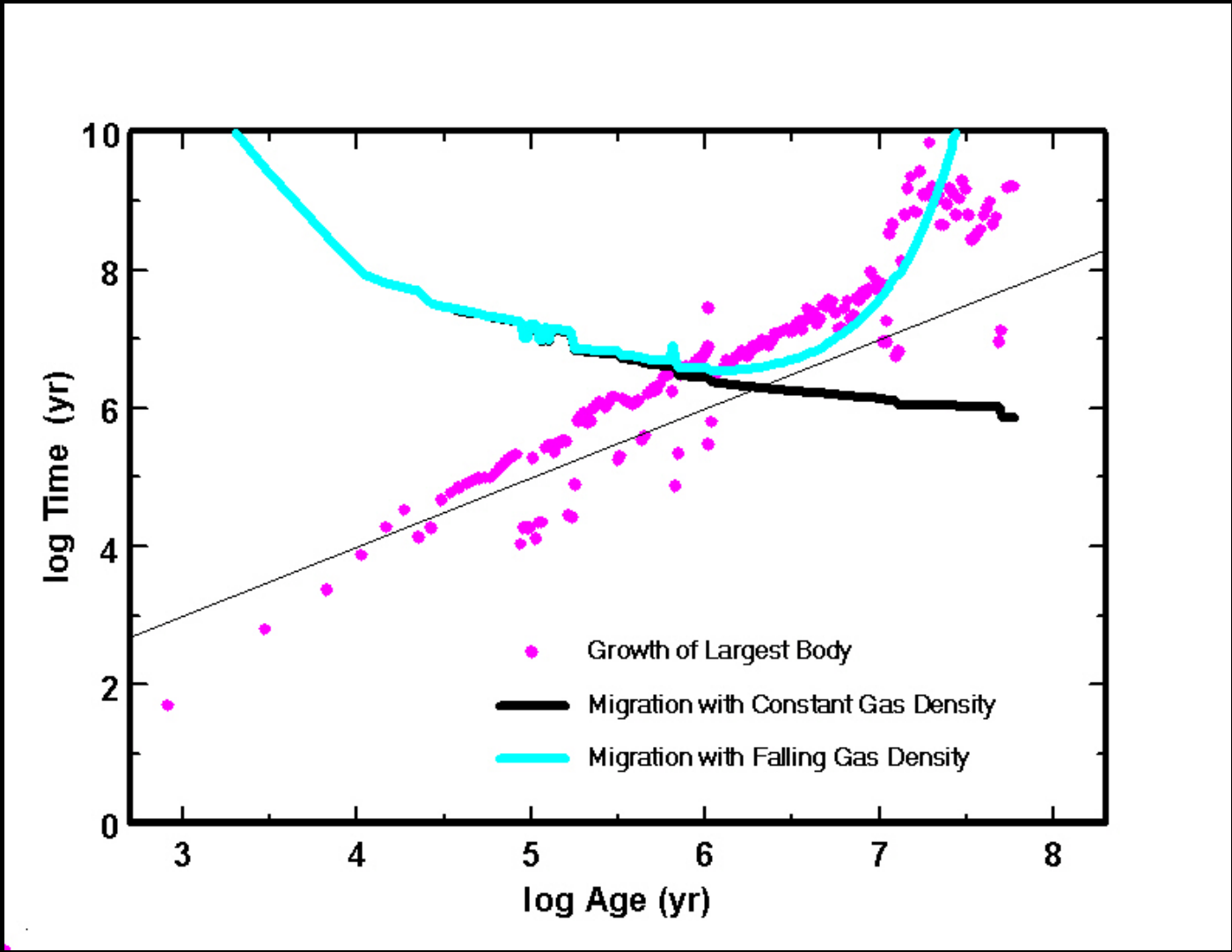
Solids

- **Grain growth: micron to mm** **Spitzer**
  - *** Fast: 1000 yr or so**
- **Grain growth: mm to km** **Turbulence**
  - ***coagulation**
  - *** instability**
- **Planet growth: km to Earths** **Spitzer**

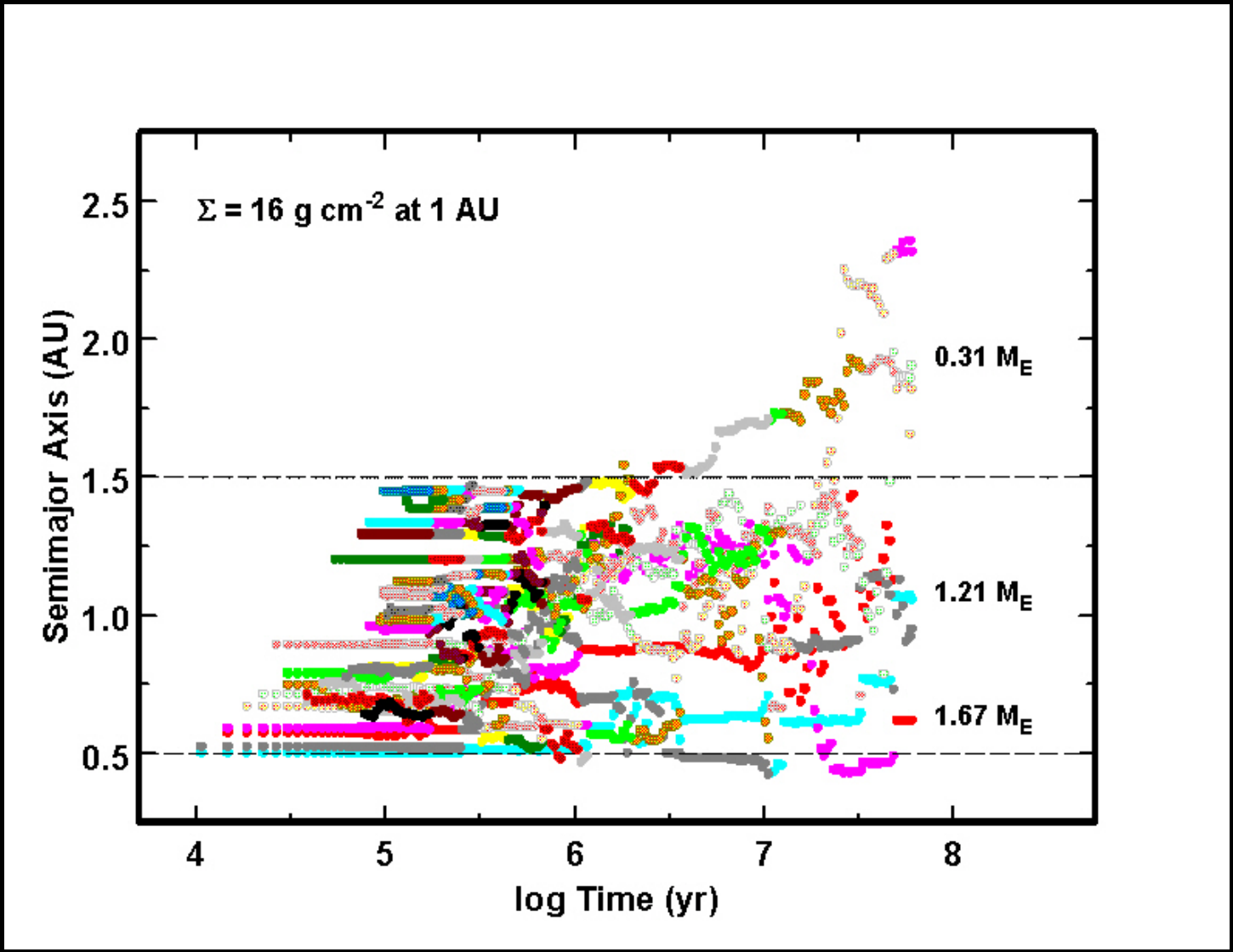
Spitzer: Evolution of Dust



Migration


log Time (yr)
log Age (yr)
0
2
4
6
8
10
3
4
5
6
7
8
Growth of Largest Body
Migration with Constant Gas Density
Migration with Falling Gas Density

Why Gas?


Σ = 16 g cm^{-2} at 1 AU
Semimajor Axis (AU)
log Time (yr)
2.5
2.0
1.5
1.0
0.5
4
5
6
7
8
0.31 M_E
1.21 M_E
1.67 M_E

Gas

- **Viscous timescale** — **Spitzer**
  - *** < 100,000 yr if no Jupiter**
- **Evaporation** — **FUV/EUV Spectra**
  - *** need T > 100,000 K**
- **Migration** — **TPF**

Stages of Growth

- **Linear Growth - F_g small**
  - * damping & dynamical friction
- **Runaway Growth - F_g large**
  - * viscous stirring
- **Oligarchic Growth**
  - * isolation
- **Chaotic Growth**
  - * largest grow fastest
- **Final Accumulation**