Hot Debris Disks and Giant Impacts

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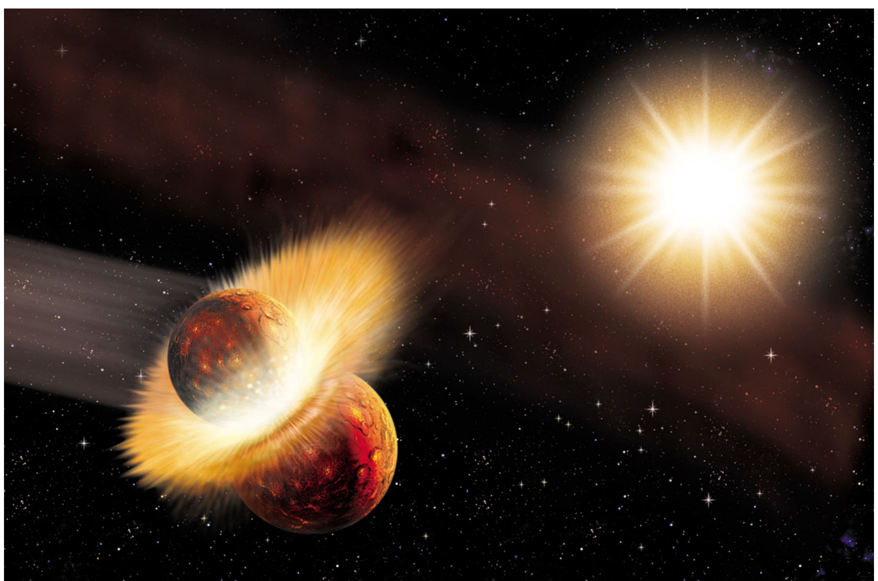
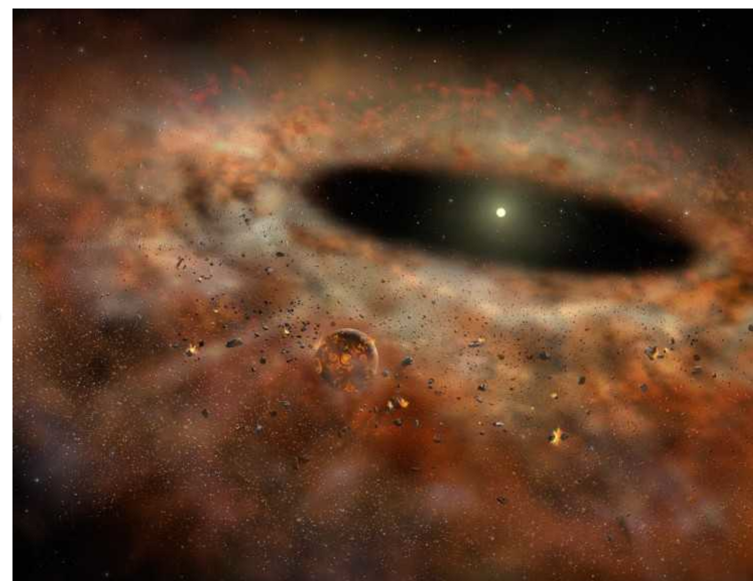
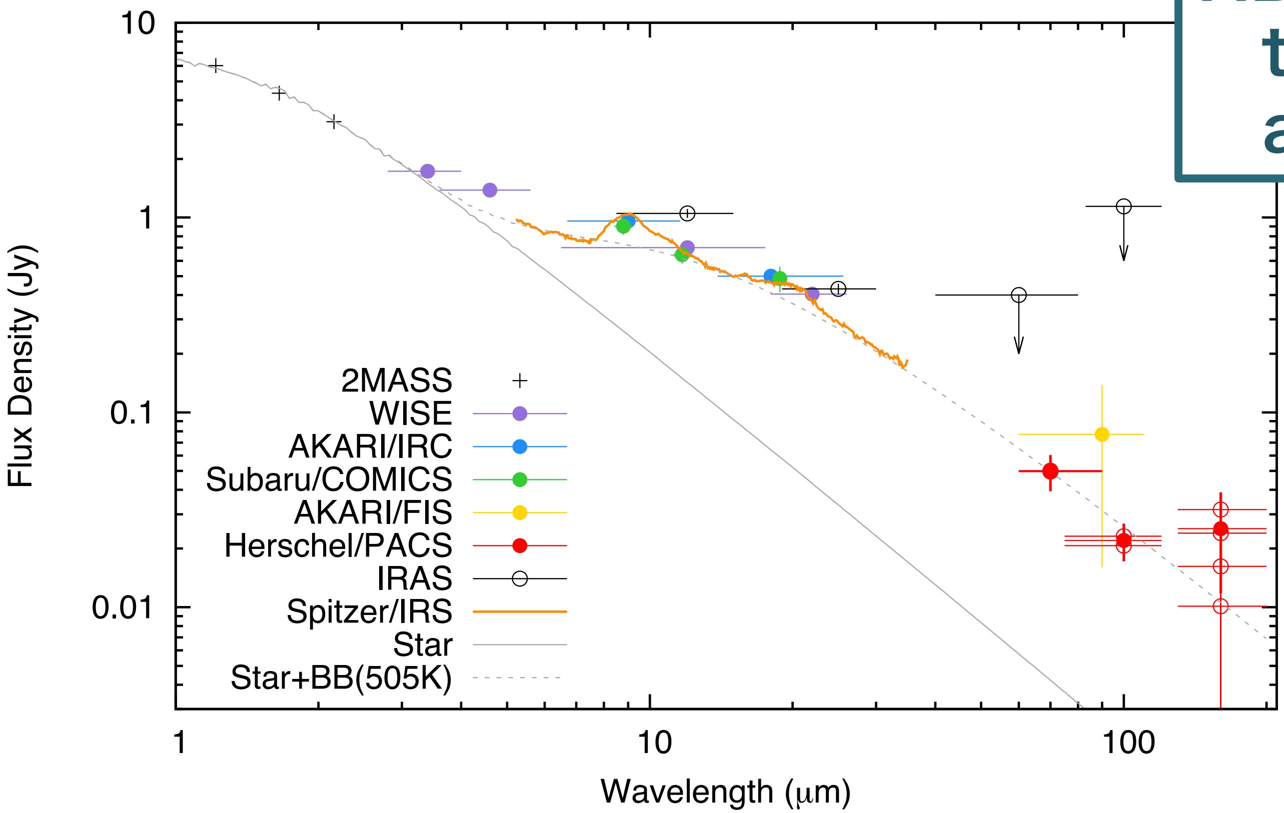




Obs. of Hot Debris Disk

HD15407A
type : F5V
age : 8x10^{7}year



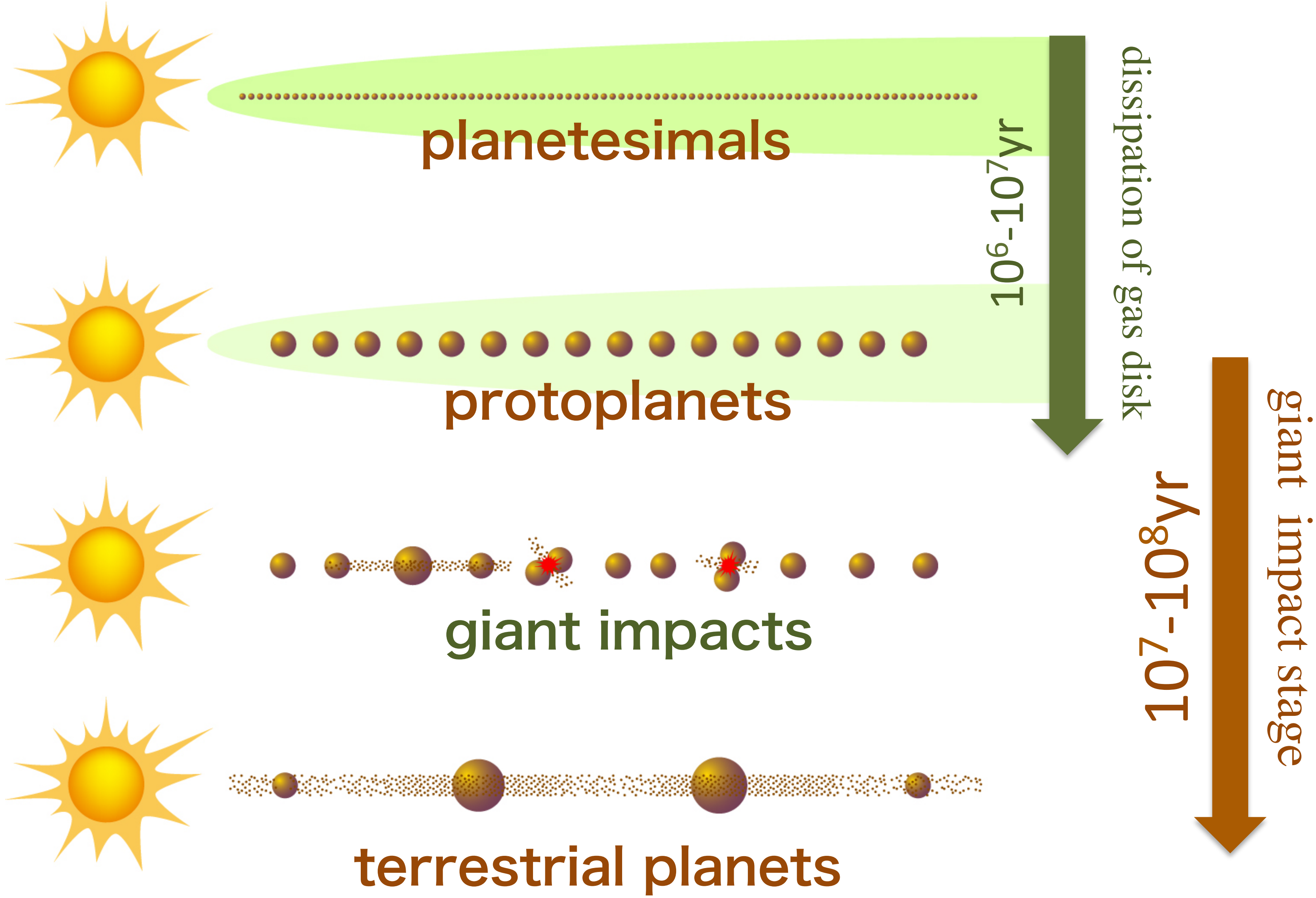
Fujiwara et al. (2012)
Melis et al. (2010)

Infrared excess near 10μm (～300K)

Recently the linkage between infrared excess of the stars (10^7-10^8yr) and terrestrial planet formation has been discussed.

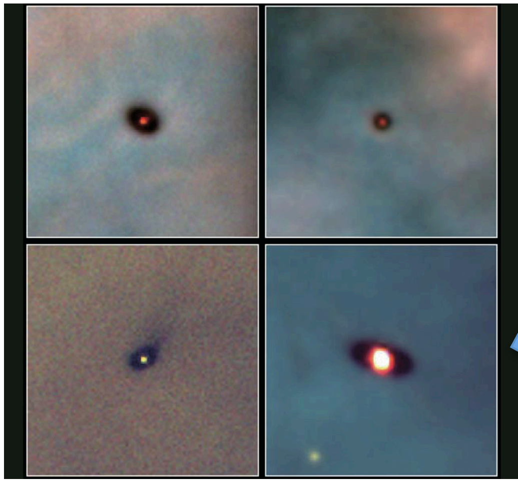
Weinberger et al. 2011, Jackson & Wyatt 2012, Melis et al. 2012, etc.

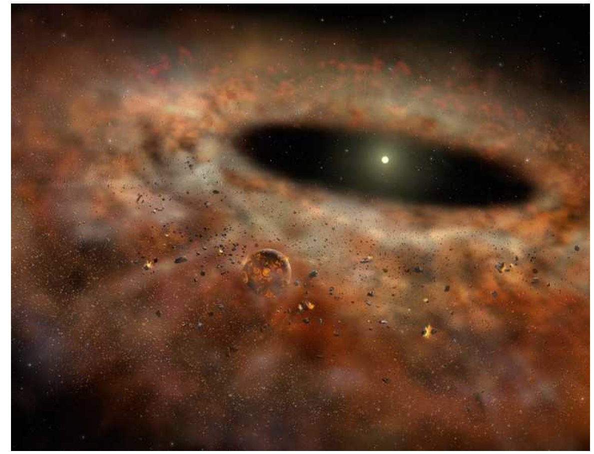
Terrestrial Planet Formation



Kokubo & Ida (1996,1998), Ogihara & Ida (2009), Kokubo & Genda (2012), etc.

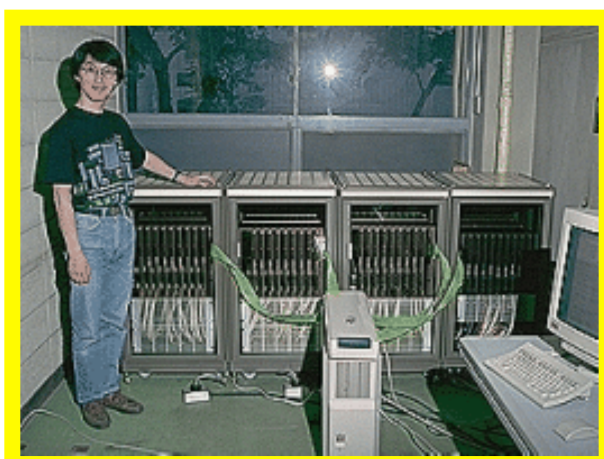
Planet Formation Theory

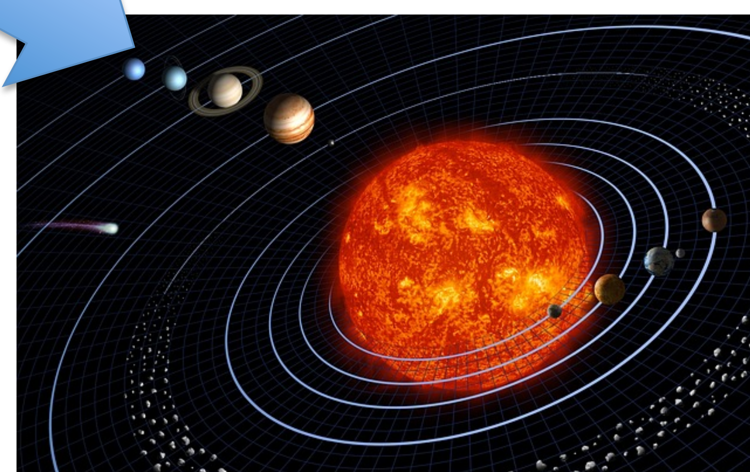




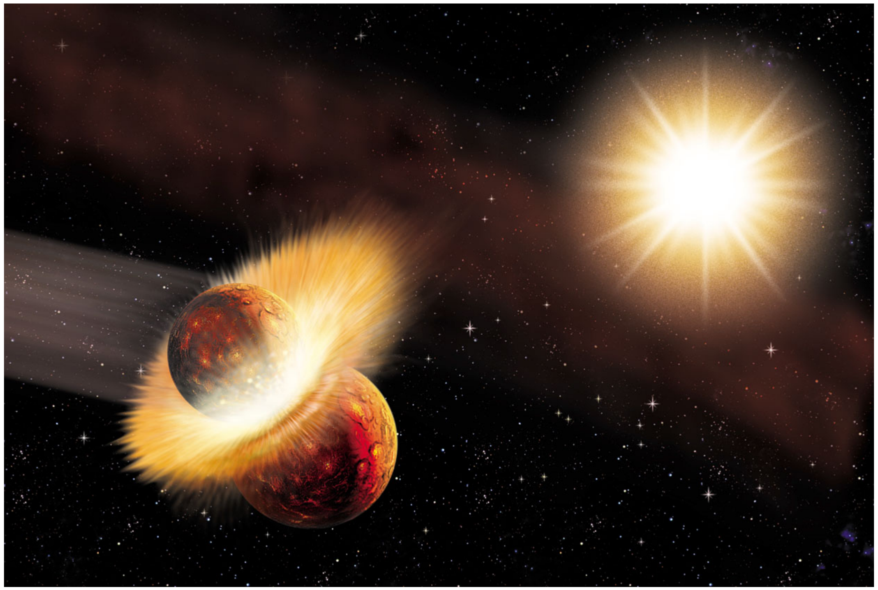
Obs. of planet formation!

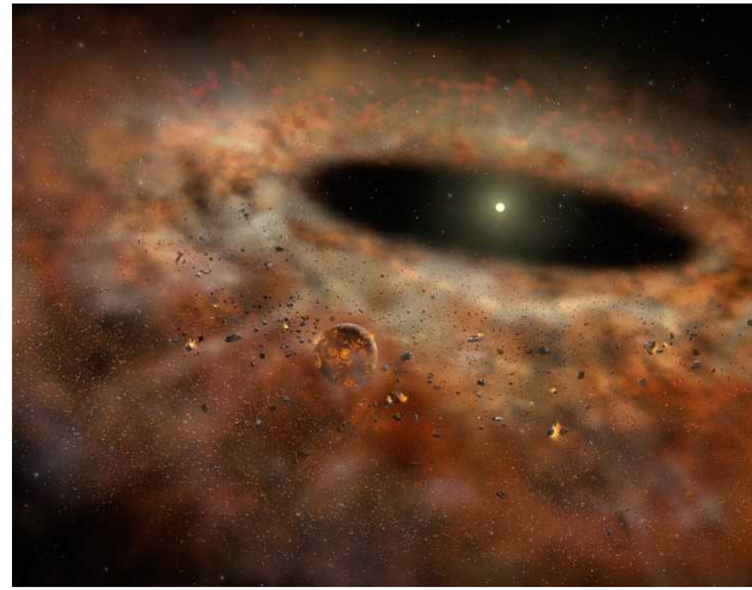
Computer Simulations!





This Study





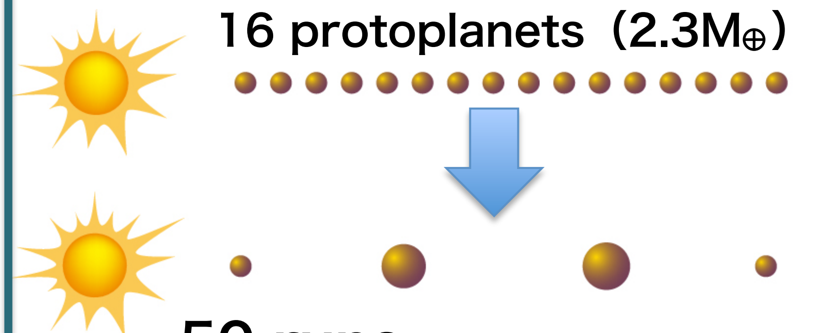
- How much debris is produced by a giant impact?
- Can we observe infrared excess throughout the giant impact stage?

Method

giant impact stage

N-body code
(Kokubo & Genda 2010)

16 protoplanets ($2.3M_\oplus$)

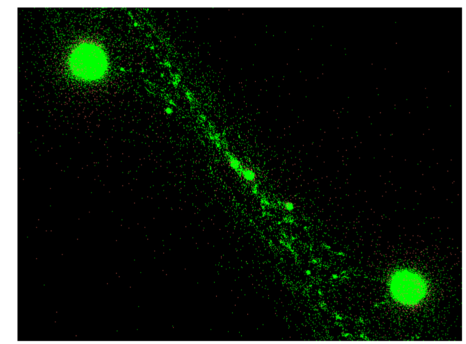


50 runs
1211 giant impacts

impact condition
time, location, masses,
impact v, angle

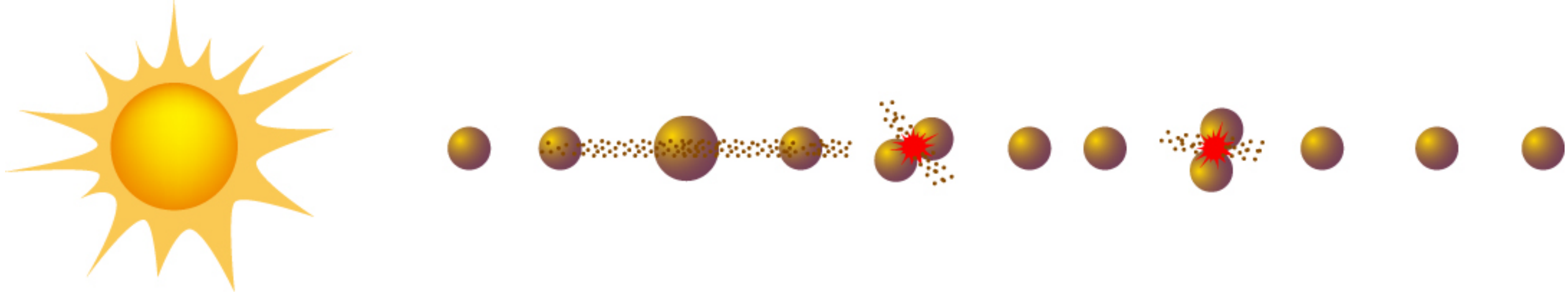
giant impact events

SPH code (Genda et al. 2012)
10^5 particles



total ejected mass
mass of largest ejected body

3 runs, 99 giant impacts



Giant impacts supply debris.

time, location, ejected mass, largest body

μ-sized debris ➡ cleared by stellar radiation pressure

Collision among debris ➡ change in size distribution

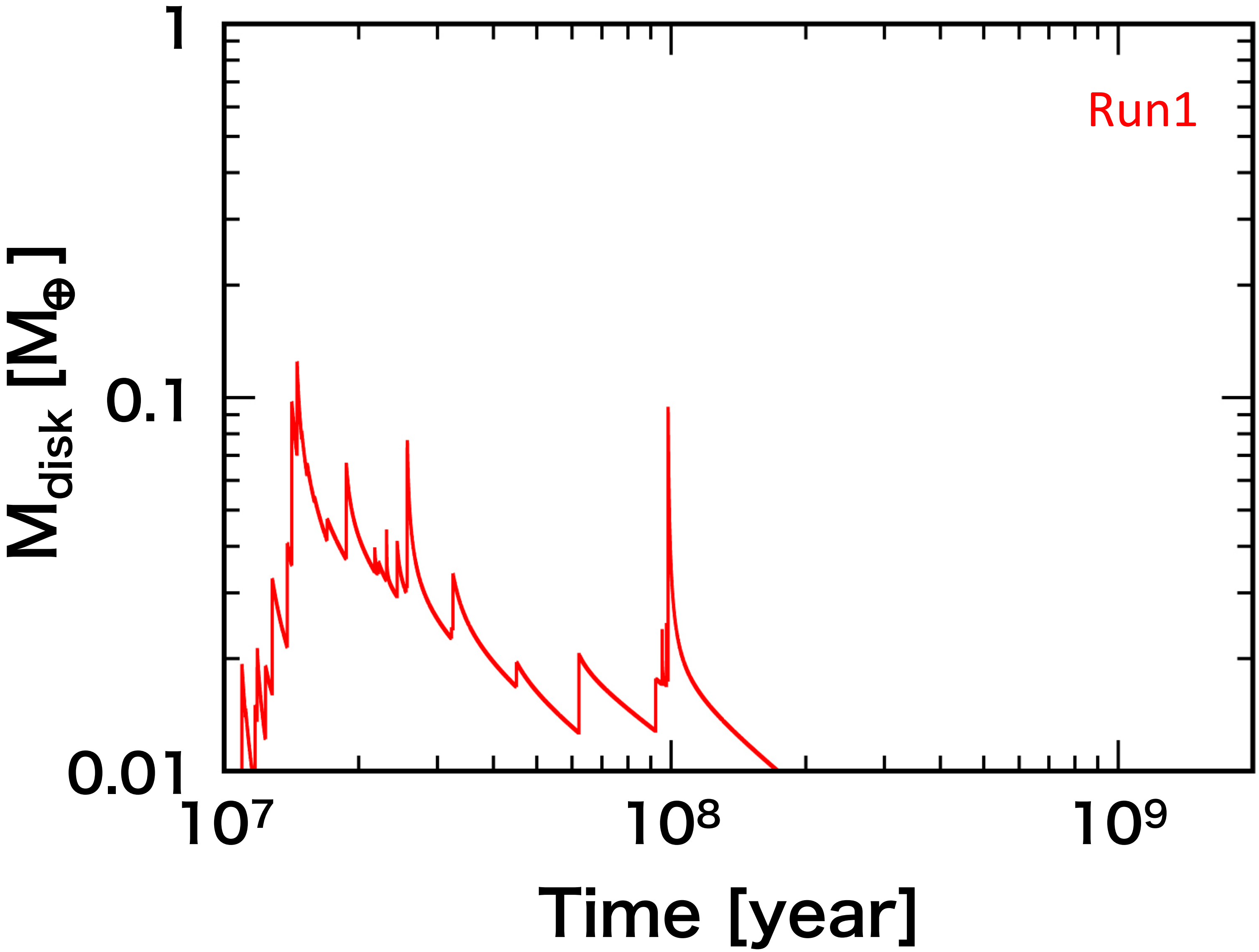
Semi-analytical model for collision cascade

Kobayashi & Tanaka (2010)

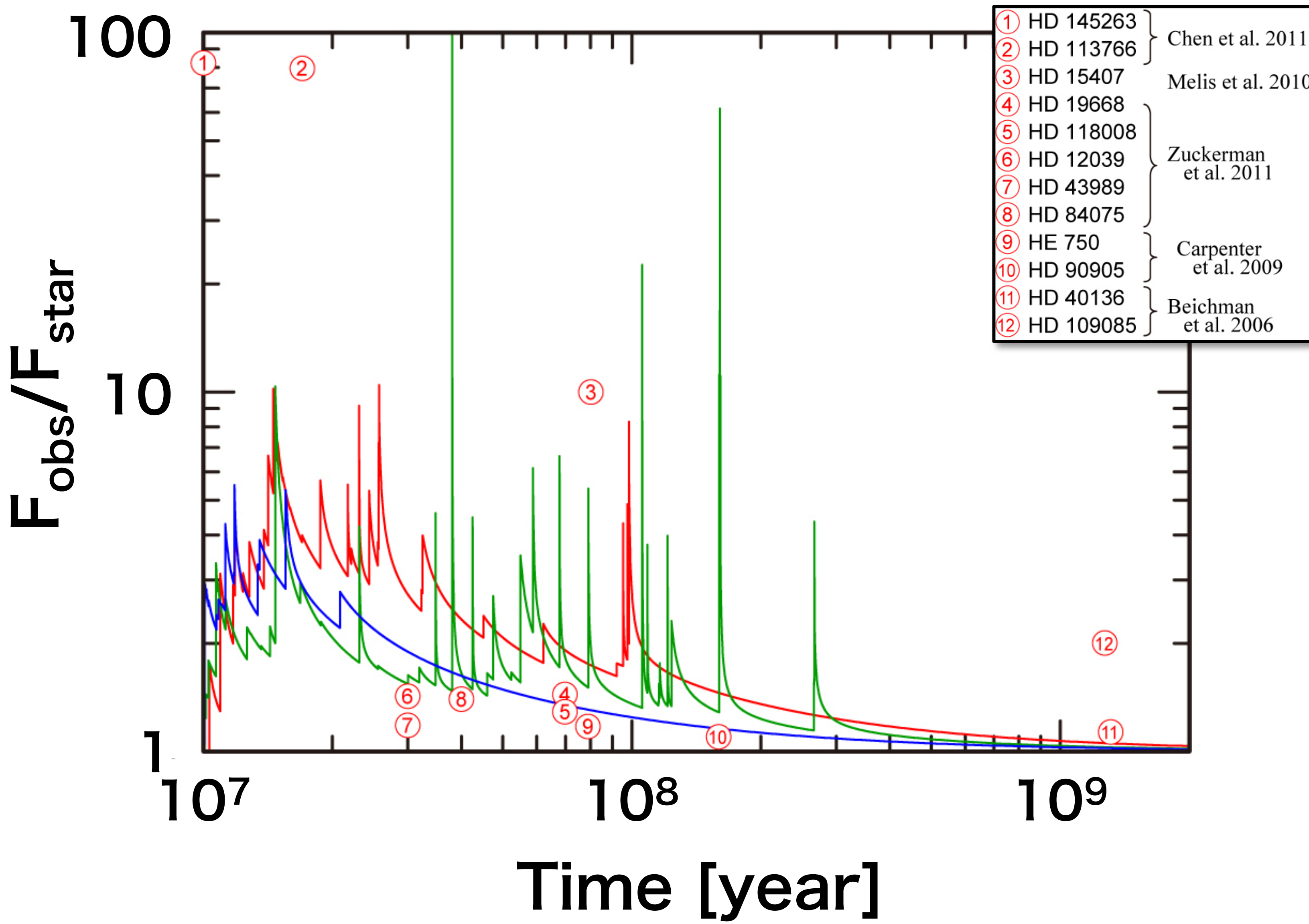
$$\tau_{dep} = 4.2\times10^{6} \left(\frac{m}{6\times10^{22}\,\mathrm{kg}}\right)^{0.64} \left(\frac{a}{1\mathrm{AU}}\right)^{4.18} \left(\frac{\Delta a/a}{0.1}\right) \left(\frac{e}{0.3}\right)^{-1.4} \left(\frac{M_{\mathrm{tot}}}{6\times10^{23}\,\mathrm{kg}}\right)^{-1} \mathrm{yr}$$

surface density of debris disk, size distribution of debris disk

Evolution of Debris Disk



Infrared Excess (24μm)

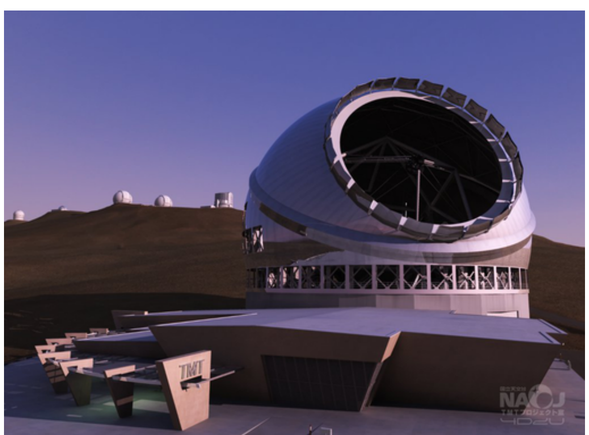


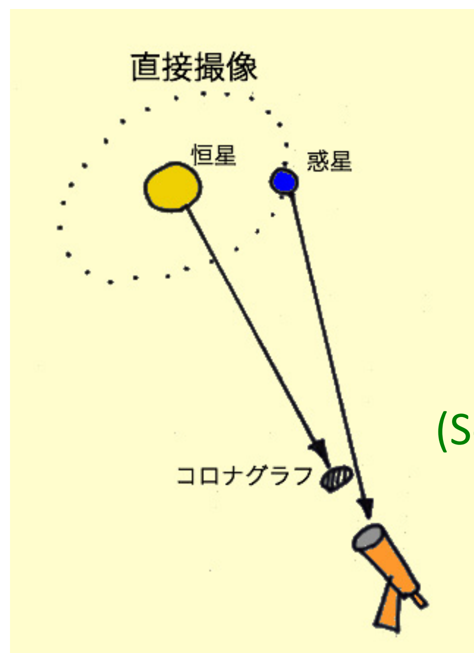
Obs. of Scattered Light

Can we observe the structure of a hot debris disk by using future telescope and instrument?

TMT (2021-)

(Thirty Meter Telescope)



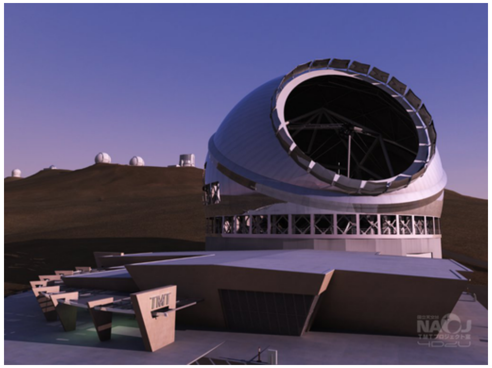


SEIT

(Second Earth Imager for TMT)

Spec of TMT&SEIT

TMT（2021～）



contrast : $10^{-8.5}$(H) 10^{-8}(J), $10^{-7.5}$(Y)

Spatial resolution, IWA : ~ 10 mas

Target object

10pc	➡	0.1AU	➡	fine structure of debris disk
30pc	➡	0.3AU	➡	global structure of debris disk
100pc	➡	1.0AU	➡	with or w/o debris disk

Summary

- Significant amount of debris ($\sim 0.4 M_{\oplus}$) is ejected throughout the giant impact stege.
- Hot debris disk lasts for $\sim 10^8$ yr, and can be observed as infrared excess.
- Using future telescope (TMT) and instrument (SEIT), we will be able to observe the structure of hot debris disk.