Estimation of the number of stellar encounters:

The kinetic theory complemented by gravitational focusing can estimate analytically the encounter time $t_{\text{enc}}$ (Binney & Tremaine):

$$t_{\text{enc}} = 1.910^{-8} \left( \frac{n}{1000 \text{ pc}^{-3}} \right)^{-1} \left( \frac{\sigma}{1 \text{ km/s}} \right)^{-1} \left( \frac{d_{\text{enc}}}{100 \text{ AU}} \right)^{2} + 8.810^{-9} \left( \frac{m_c + m_p}{1 M_{\odot}} \right) \left( \frac{n}{1000 \text{ pc}^{-3}} \right) \left( \frac{d_{\text{enc}}}{100 \text{ AU}} \right) \left( \frac{\sigma}{1 \text{ km/s}} \right).$$

valid for 2 stars, the central star and passing star of our problem, of masses $m_c$ and $m_p$, moving in a field with uniform star number density $n$ (/ for each stellar spectral type).

This star number density $n$ is taken to be a linear function of time over the open cluster lifetime.

The number of stellar encounters of miss distances $d < d_{\text{enc}}$ can be tracked by the phase in cycle:

$$d_{\text{enc}} = \int_{0}^{\text{cluster} - \text{lifetime}} t_{\text{enc}} \, dt.$$

Simulation of stellar flybys:

The debris disk has inner and outer radii of 40 and 100 AU, and is non self-gravitating. The central star is at the origin of the coordinate system. The trajectory of the passing star is parabolic, coplanar and prograde with respect to the disk (clock wise). The mass ratio between the two stars is unity. At the closest approach, the miss distance is 200 AU and the maximum velocity is 4.5 km/s. The fraction of planetesimals stripped off the disk is 35% during this close stellar encounter.

Results:

Simulations (10 000 particles under sole gravitational forces of the central star and planet) have provided the fraction of stripped planetesimals as a function of the encounter miss distance and the ratio of the masses of the central and passing stars. Figure: solid lines for an initially non excited disk (circular initial orbits), dotted lines for an initially dynamically excited disk (excentric initial orbits). Table: stripped planetesimals by stellar flybys after 100 Myr.

Conclusions:

We have found that:
1) depletion is insignificant in disks around stars born in embedded clusters with low star number densities (< 1000 pc$^{-3}$).
2) depletion is significant in disks around stars born in high star number density embedded clusters such as the Orion Nebula Cluster with a core stellar density of 20 000 pc$^{-3}$. In these conditions, debris disks lose > 96% of their planetesimals around M-dwarfs, > 86% around solar-type stars and > 71% around A stars in 100 Myr.

High depletion in high density clusters could affect 2/3 of the stars searched for debris disks in surveys since 2/3 of them are born in high stellar density embedded clusters according to the catalog of Lada and Lada (2003).

We have found also that this depletion depends significantly on the mass of the central star in our model, and, interestingly, this is consistent with the observations that have revealed that less debris disks are detected around low-mass stars.