Rates and Rotation: Direct Collapse

Two Types: Collapsar ($40\,M_\odot < M_{Prog} < 100\,M_\odot$)
Very Massive Objects (VMOs) ($M_{Prog} > 270 M_\odot$)

Rate: Collapsar
Depends Sensitively on IMF, Mass Loss, SN Calc.
$Rate_{Collapsar} = 0-0.1\ (0.016)\ Rate_{SN}$

Rate: VMO
Pop III Stars Only
IMF Favors Massive Stars, Winds not Important
Upper Limit from Ionization Photons
Produced by These Stars (Abel et al. 2000)
<1−10 million VMOs per galaxy

Rotation

Like Core−Collapse SN, the Rotation Rate
of the Collapsing Core is Currently Unknown.
Heger's Model: J up to $10^{53}\,g\,cm^2\,s^{-1}$ for VMOs