The Impact of Initial Distributions

…on binary yields…

Parameter space

$$\text{Probability of existence} = (\text{Some Probability Distribution Function}) \times d(\text{Volume})$$

$$\delta V = \begin{cases} \delta \ln M & \text{single stars} \\ \delta \ln M_1 \, \delta \ln M_2 \, \delta \ln a & \text{binary stars} \end{cases}$$

$$\delta p_i = \Psi \delta V_i = \Psi \delta V$$

$$\Psi = \begin{cases} \psi(\ln M_i) & \text{single stars} \\ \psi(\ln M_{1i}) \, \phi(\ln M_{2i}) \, \chi(\ln a_i) & \text{binary stars} \end{cases}$$

Yields

"Yield" of isotope j per unit total mass input to a population

$$y_j \quad = \quad \frac{\text{MASS OUT AS ISOTOPE } j}{\text{TOTAL MASS INTO POPULATION}}$$

Mass expelled from one star (label i) as isotope j

$$\delta Y_{ij} = \delta p_i \int_0^{t_{\max}} \dot{M}(t)\, X_j(t)\, dt$$

Mass out from a population as isotope j

$$Y_j = \sum_i \delta Y_{ij}$$

$$y_j = \begin{cases} Y_j / \sum_i \left[M_i \delta p_i\right] & \text{single stars} \\ Y_j / \sum_i \left[(M_{1i} + M_{2i}) \delta p_i\right] & \text{binary stars} \end{cases}$$

Single Star Mass Distribution

$$\psi(M) = \frac{dp}{dM}$$

Salpeter power-law ($\alpha \simeq -2.2$ or -2.7 or -1 or -4?)

$$\psi(M) = AM^{\alpha}$$

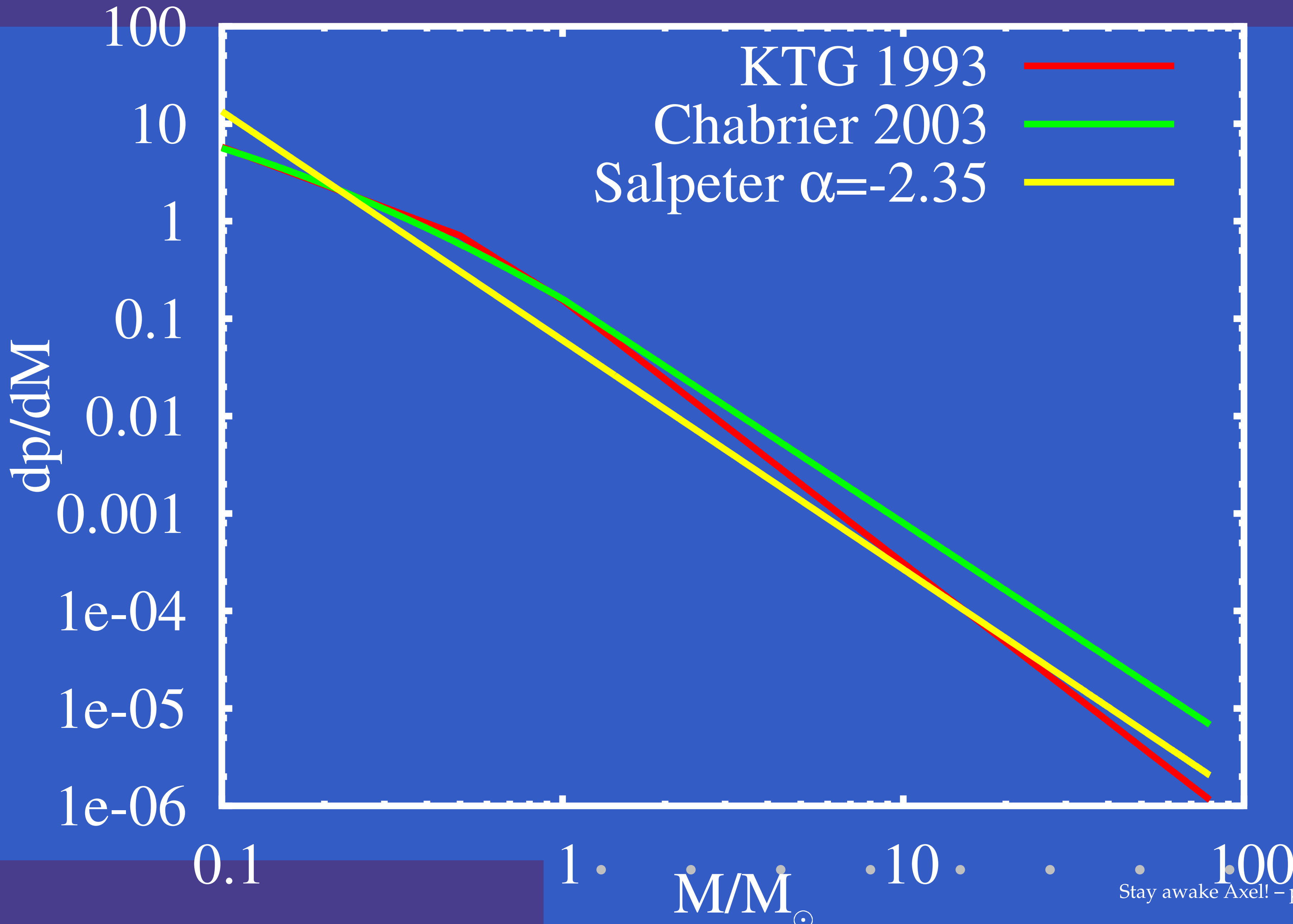
KTG 1993 three-part power-law ($p_3 = -2.7$)

$$\psi(M) = \begin{cases} 0 & M/\,\mathrm{M_\odot} \le m_0 \\ a_1(M/\mathrm{M_\odot})^{p_1} & m_0 < M/\mathrm{M_\odot} \le m_1 \\ a_2(M/\mathrm{M_\odot})^{p_2} & m_1 < M/\mathrm{M_\odot} \le m_2 \\ a_3(M/\mathrm{M_\odot})^{p_3} & m_2 < M/\mathrm{M_\odot} \le m_{\mathrm{max}} \\ 0 & m > m_{\mathrm{max}} \end{cases}$$

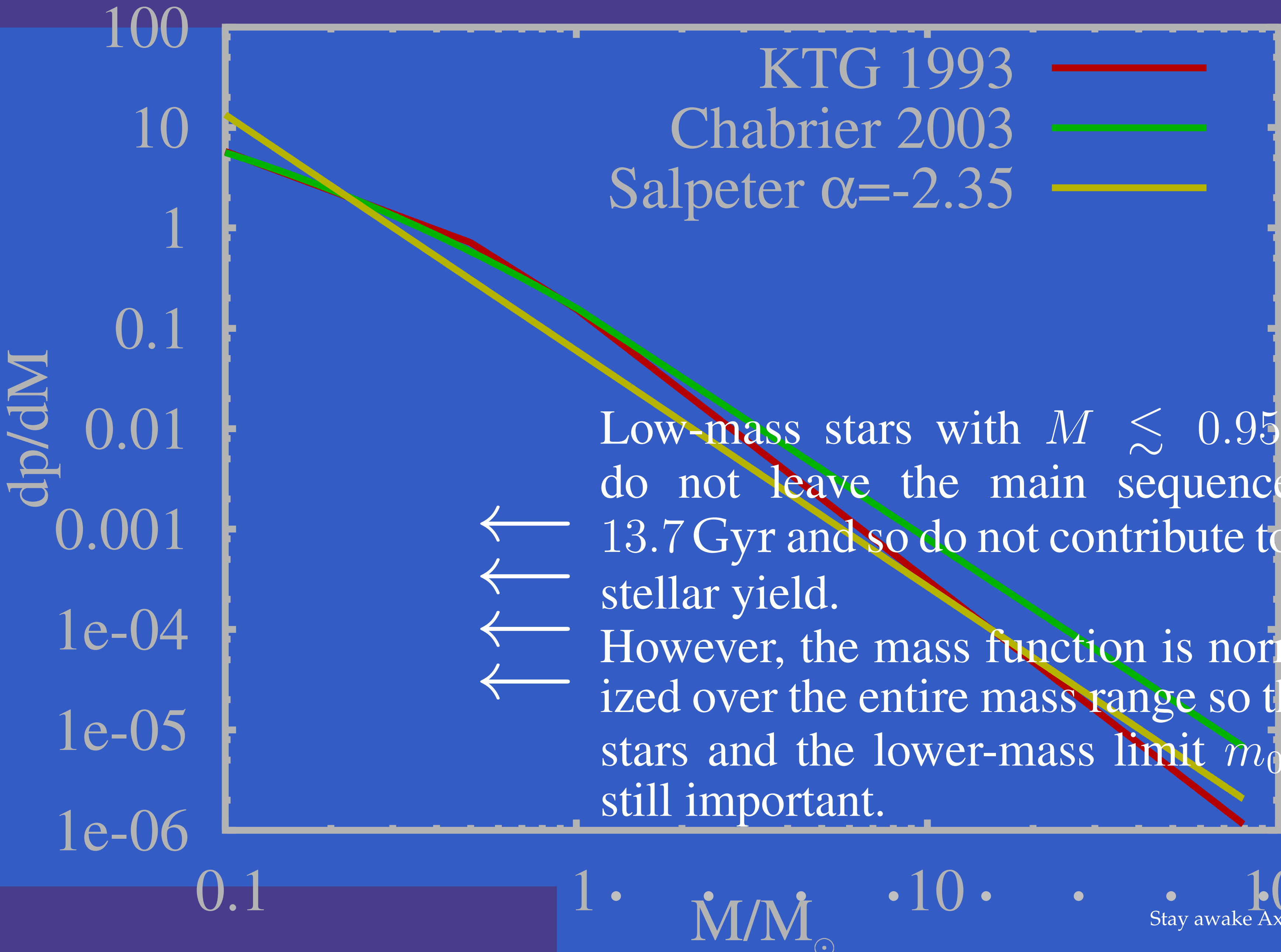
Chabrier 2003 Gaussian/power-law ($x = -2.3$)

$$\psi(\log M) = \begin{cases} A_0 A_1 \exp\left[-(\log M/\mathrm{M_\odot} - \log M_C)/2\sigma^2\right] & M < 1\,\mathrm{M_\odot} \\ A_0 A_2 (M/\mathrm{M_\odot})^{-x} & M \ge 1\,\mathrm{M_\odot} \end{cases}$$

Single Star IMFs



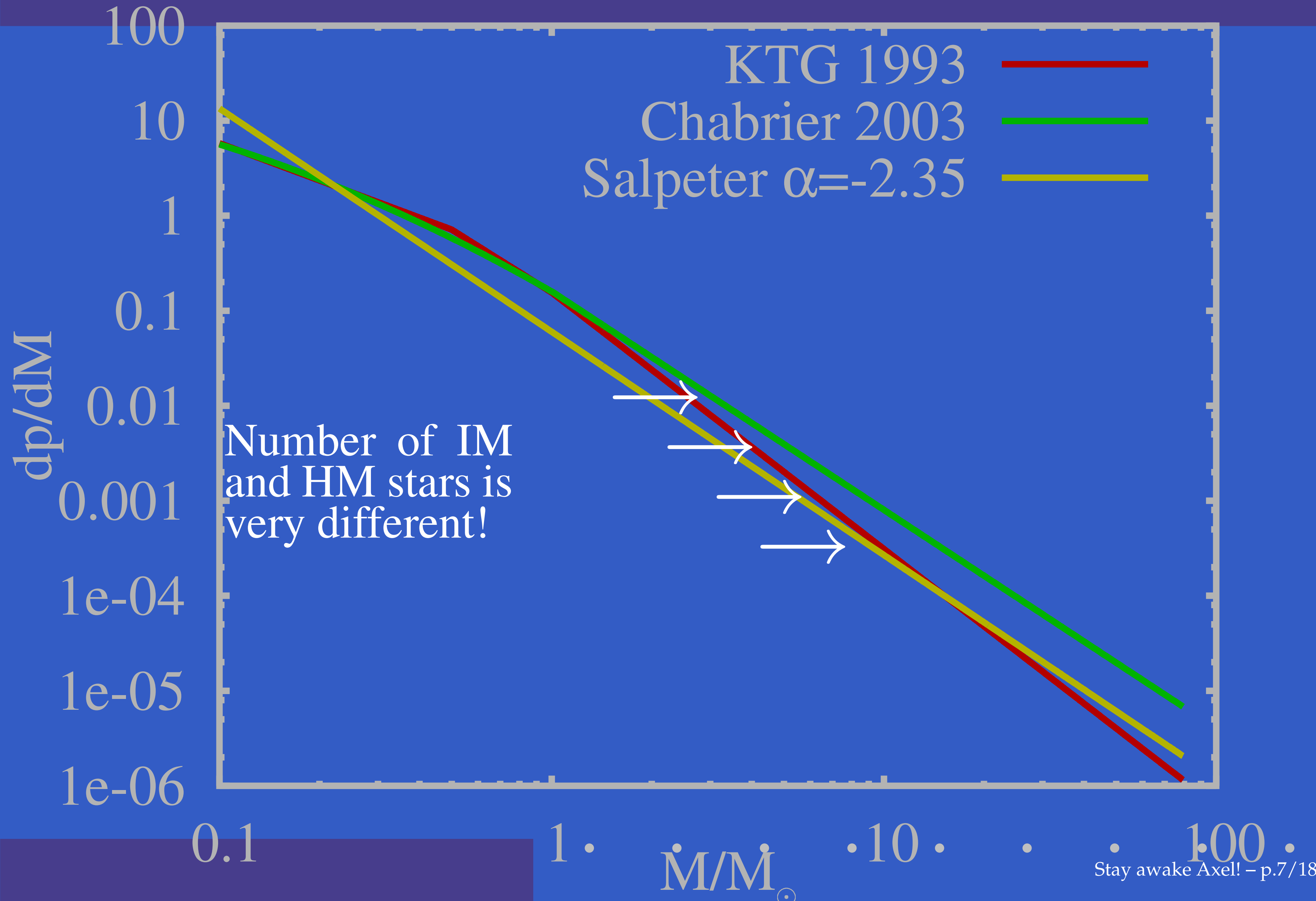
Single Star IMFs



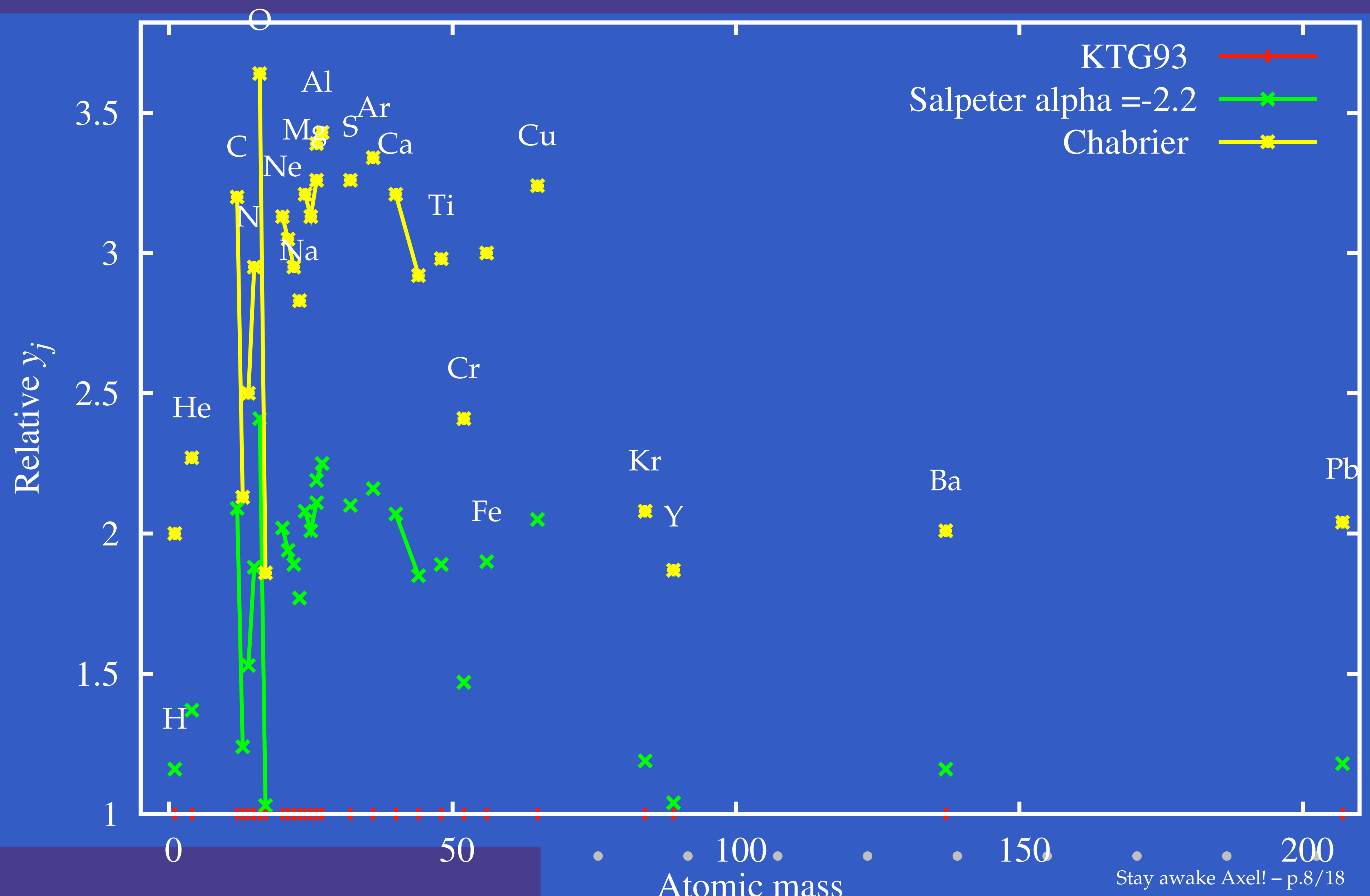
Low-mass stars with $M \lesssim 0.95\,\mathrm{M}_\odot$ do not leave the main sequence in 13.7 Gyr and so do not contribute to the stellar yield.

However, the mass function is normalized over the entire mass range so these stars and the lower-mass limit m_0 are still important.

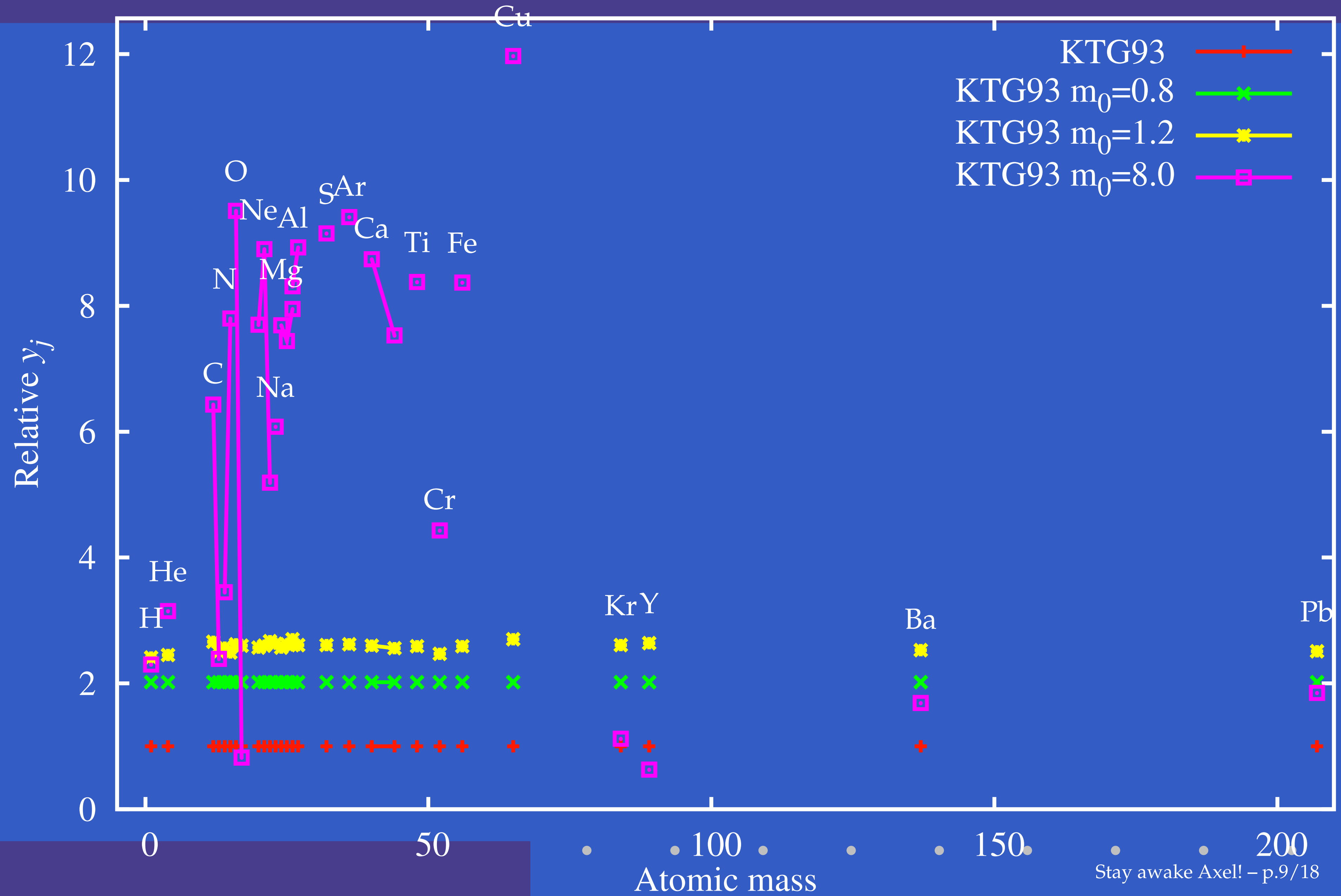
Single Star IMFs



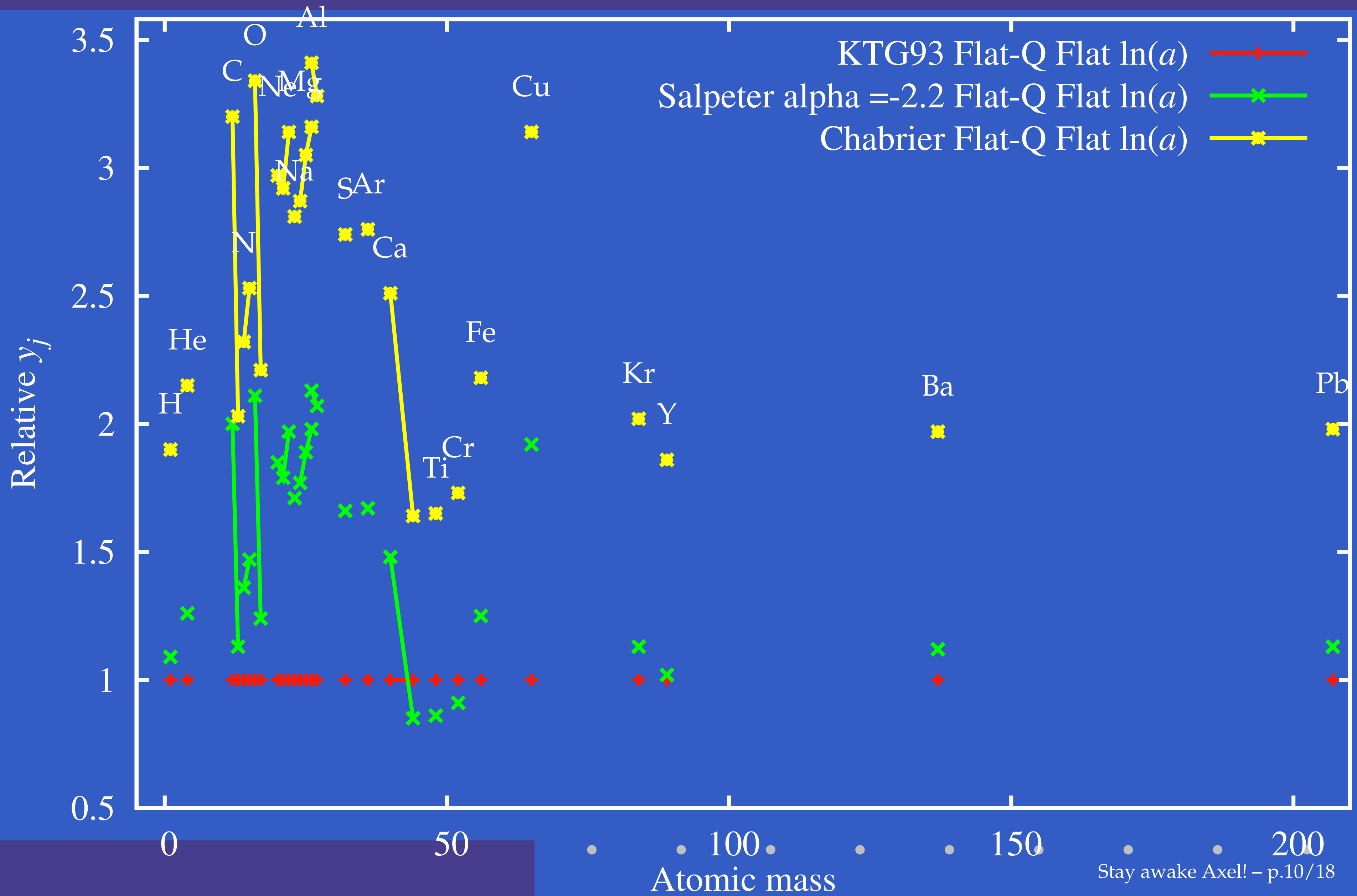
Results: Vary Single Star IMF



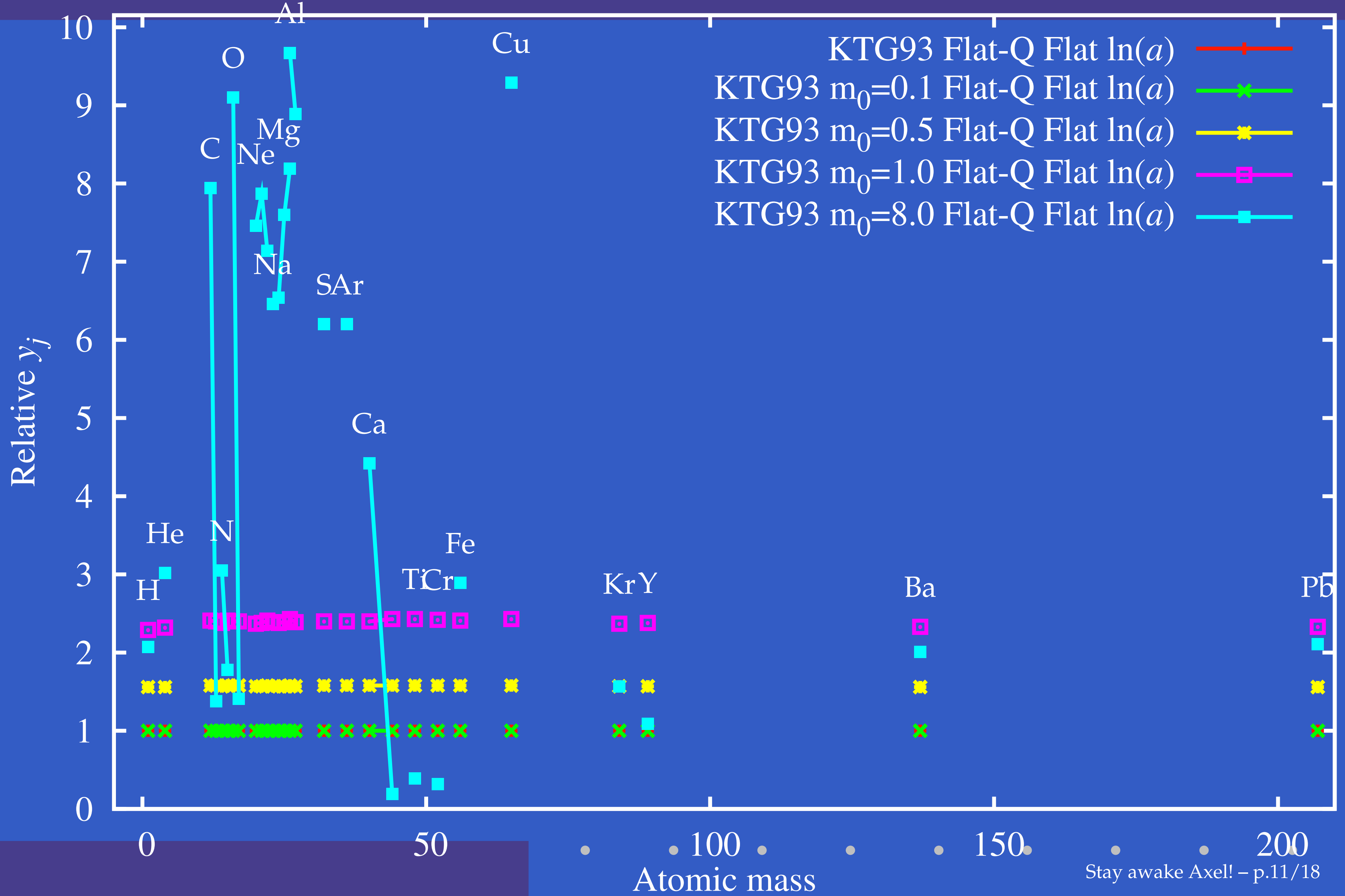
Results: Vary Single Star m_0



Results: Vary Binary Primary MF

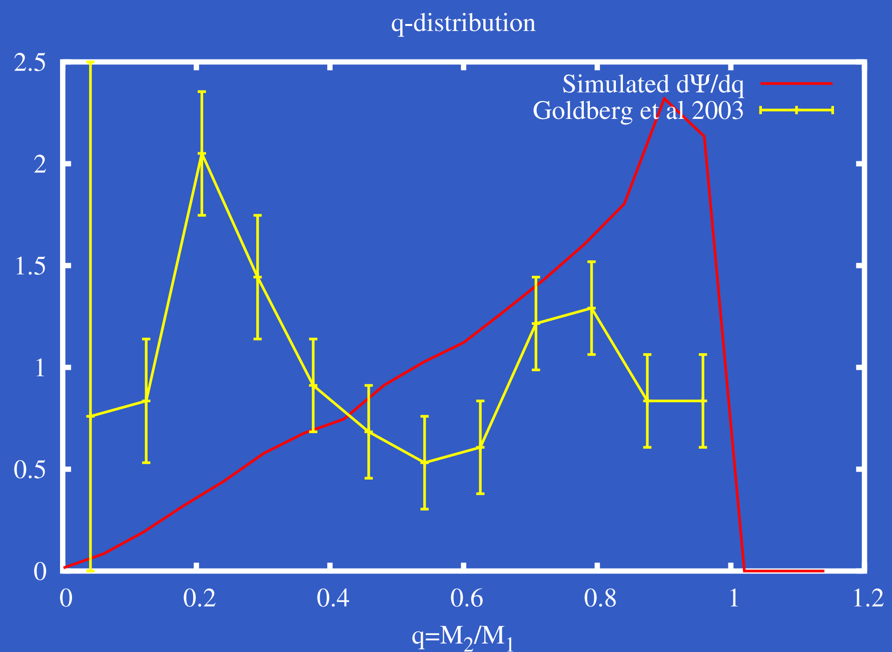


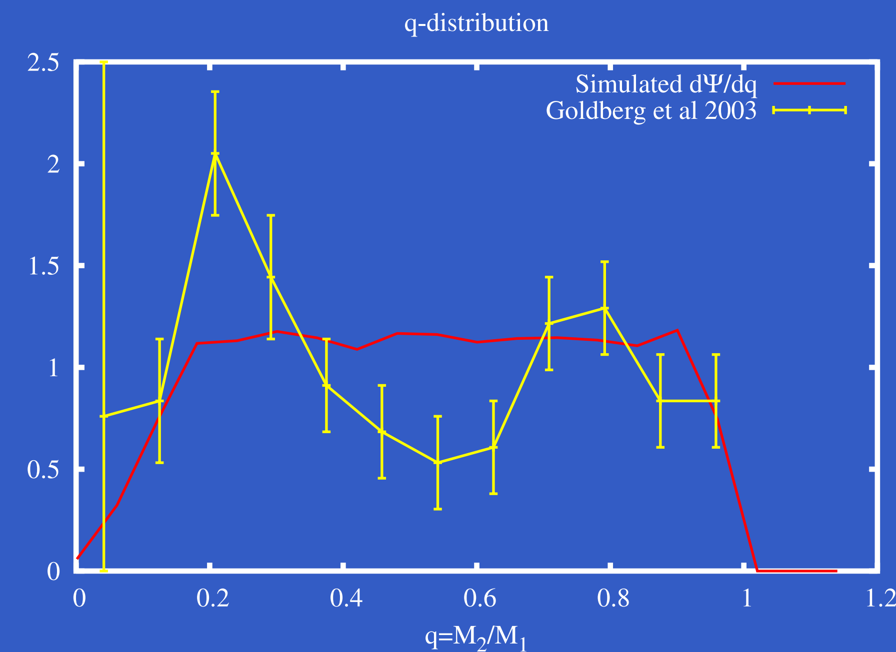
Results: Vary Binary Primary m_0



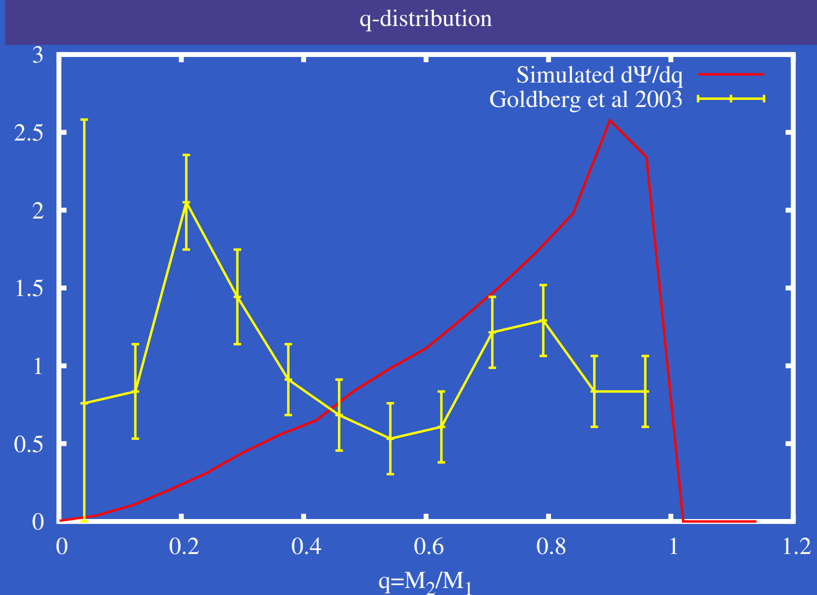
Secondary Star Mass or q-distribution

- $q\phi(q) = q\frac{dp}{dq} = \phi(\ln M_2)$
- Standard: flat-q for $q_{\rm min} \le q \le 1$ ($q_{\rm min} = 0.1/M_1$)
- Again sensitive to m_0 ($= 0.1, 0.5$): tweak→match obs ($m_0 \sim 0.4$)

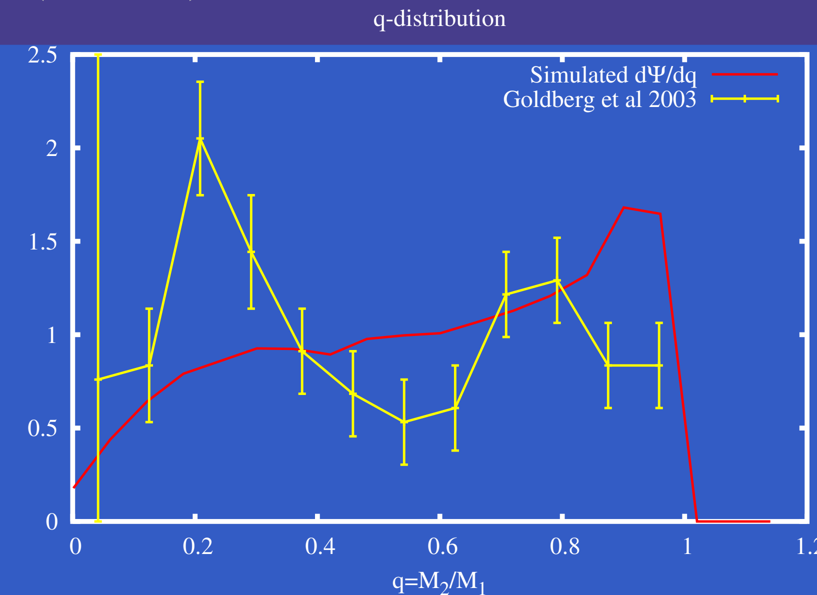




Other distributions (BS)

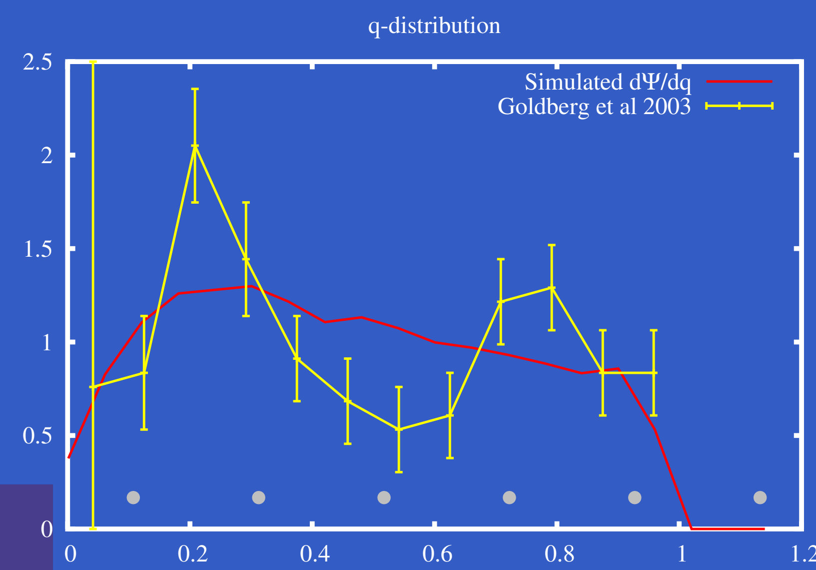


$\phi \sim q^{0.5}$

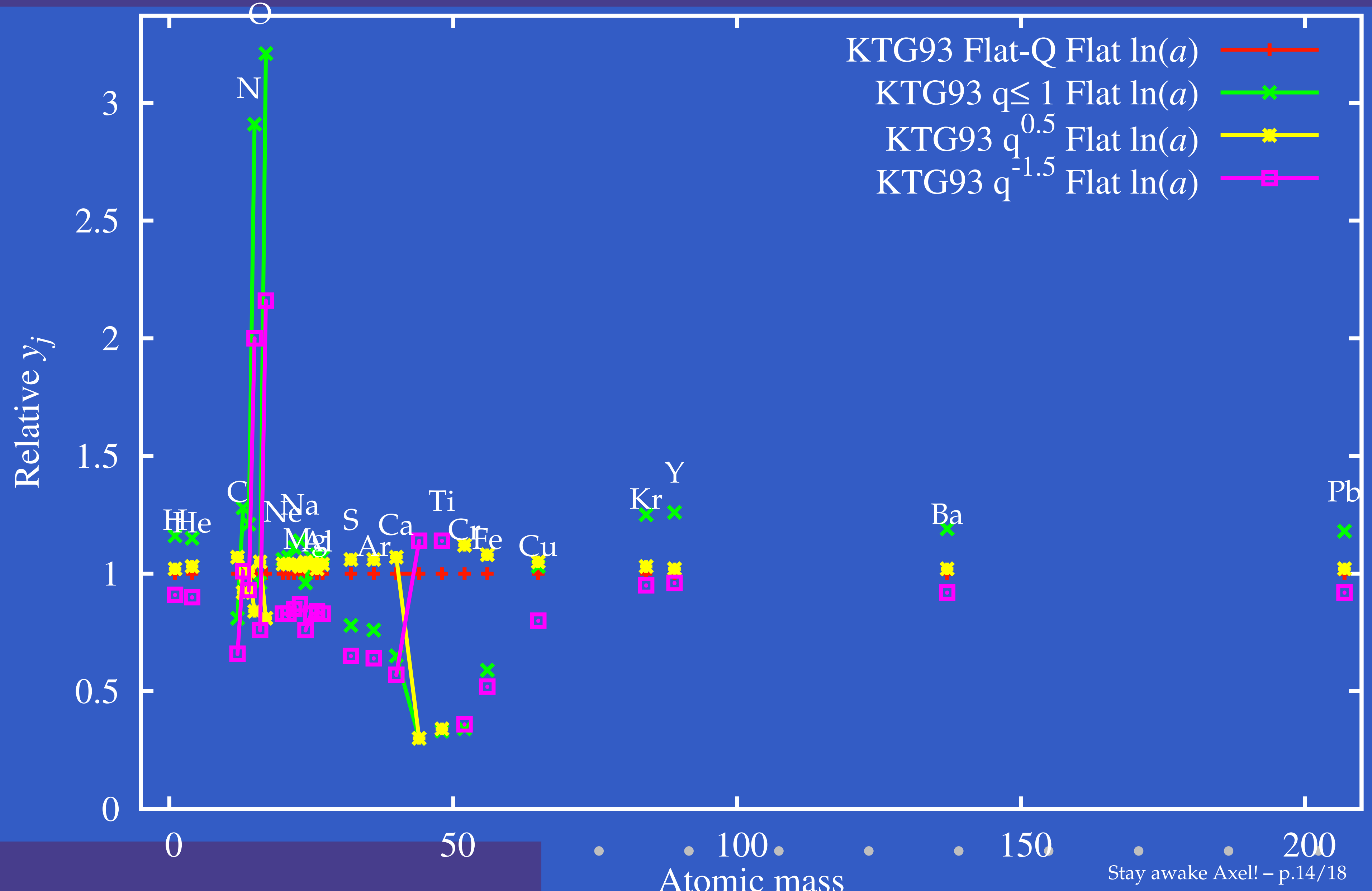


$\phi \sim q^{-1.5}$

IMF-IMF



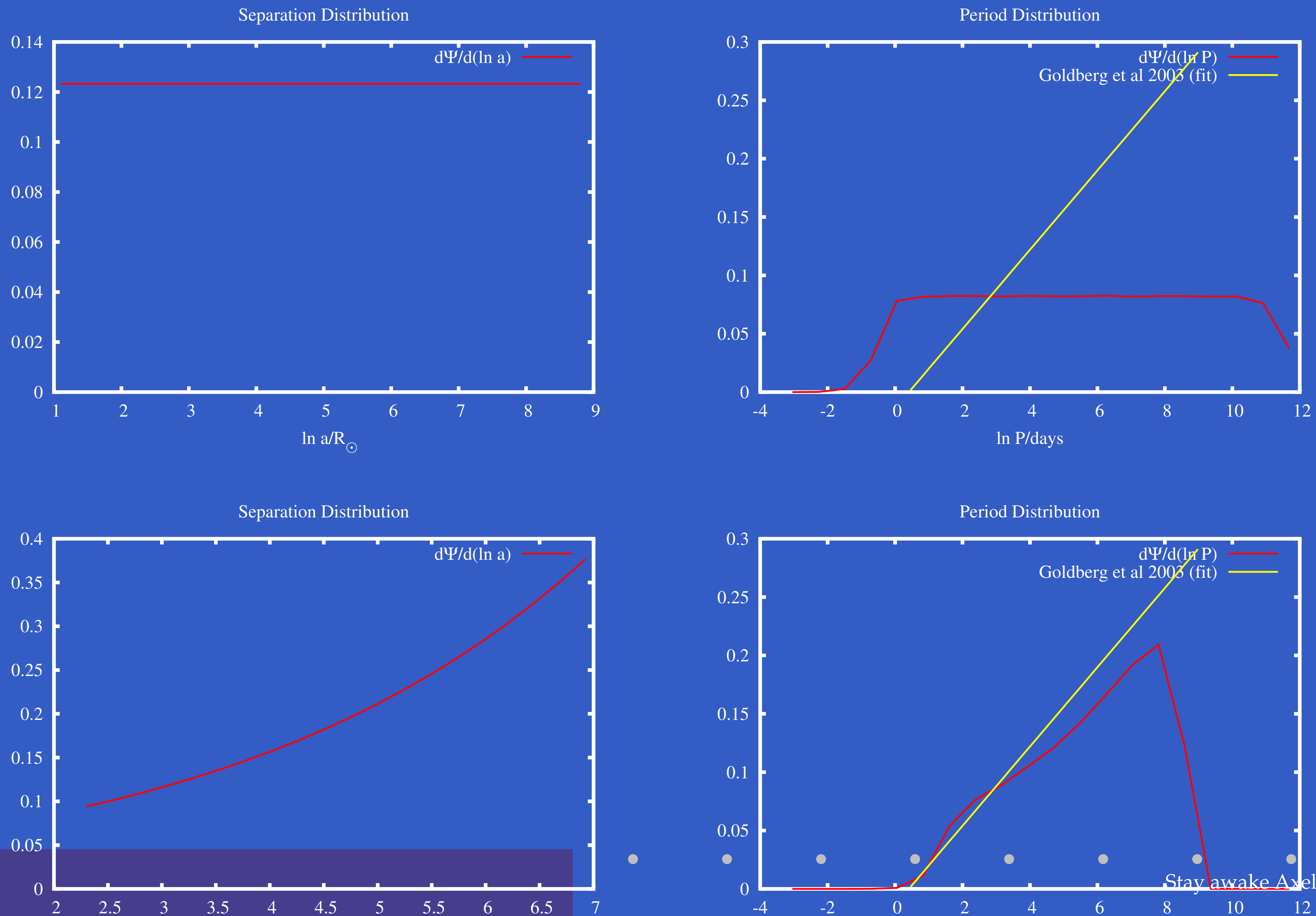
Results: Vary Binary q-dist



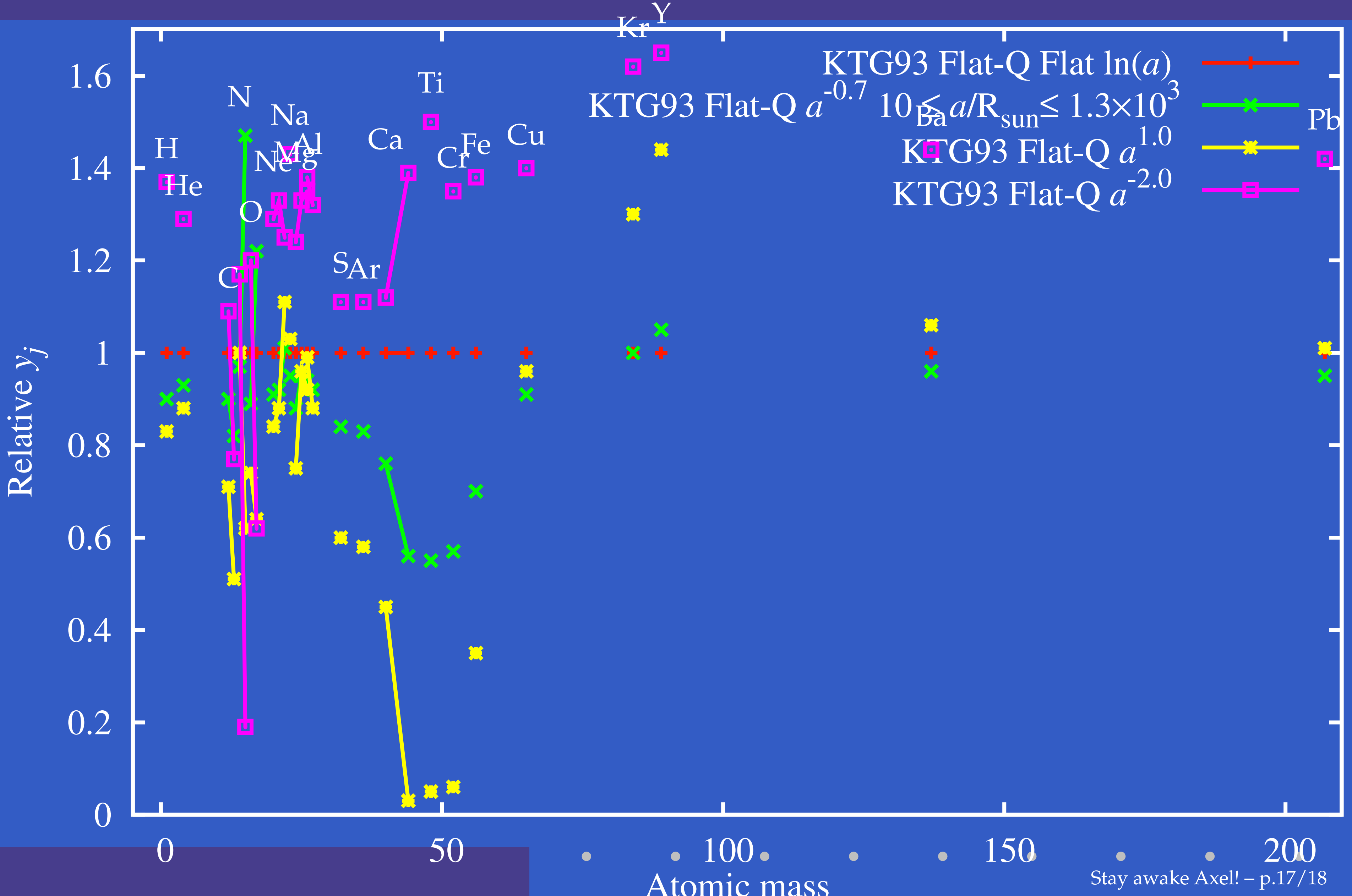
Period/Separation (a) Distribution

- Typical: Flat in $\ln a$
- Try a^x (what is x?!)
- Fit to observations $\psi(a) \sim a^{-0.7}$ (with $10 \leq a/\mathrm{R}_\odot \leq 1.3 \times 10^3$)
- Period from Kepler's law $P^2 = \frac{a^3}{(M_1+M_2)}$ (solar units)

Period/Separation (a) Distribution



Results: Vary Binary a-dist



Conclusion

- Accurate initial distributions are VITAL to the calculation of yields from binary stars.
- We currently do not have accurate initial distributions.
- Effect of varying the distributions $\gtrsim$ effect of varying physics!
- ARGH!
- What is the effect on number counts of R(J(N(C(S)))) stars?