

Examining the Age Activity Relationship of Ultracool Dwarfs with GAIA

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GAIA Brown Dwarfs
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What do I mean by Activity?

Emission related to the presence
and strength of a magnetic field

x-ray

UV

radio

spots

H α emission

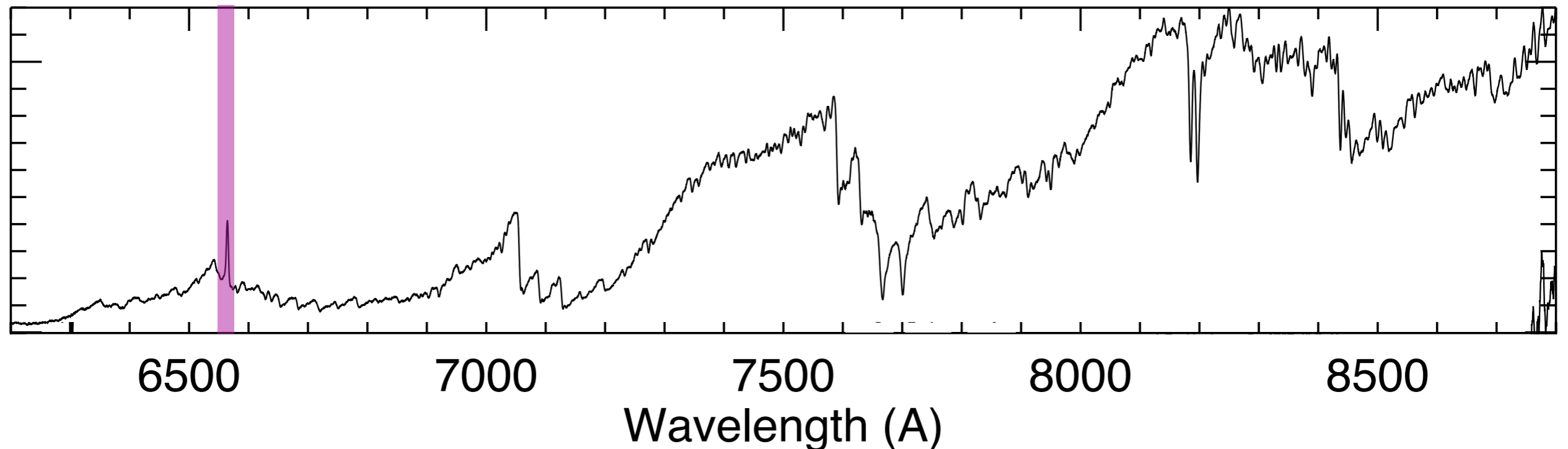
flares

Ha emission

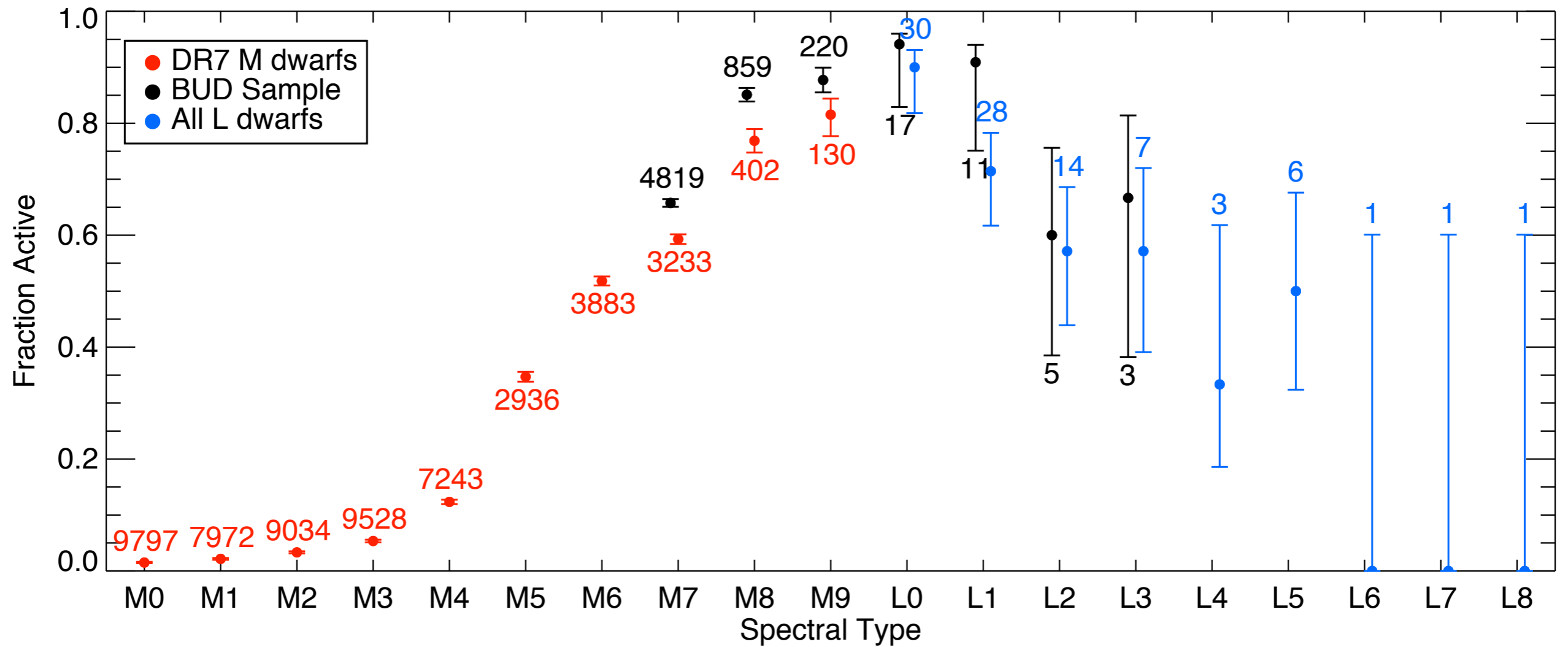
presence and strength

indicates a heated chromosphere

shows low-level variability



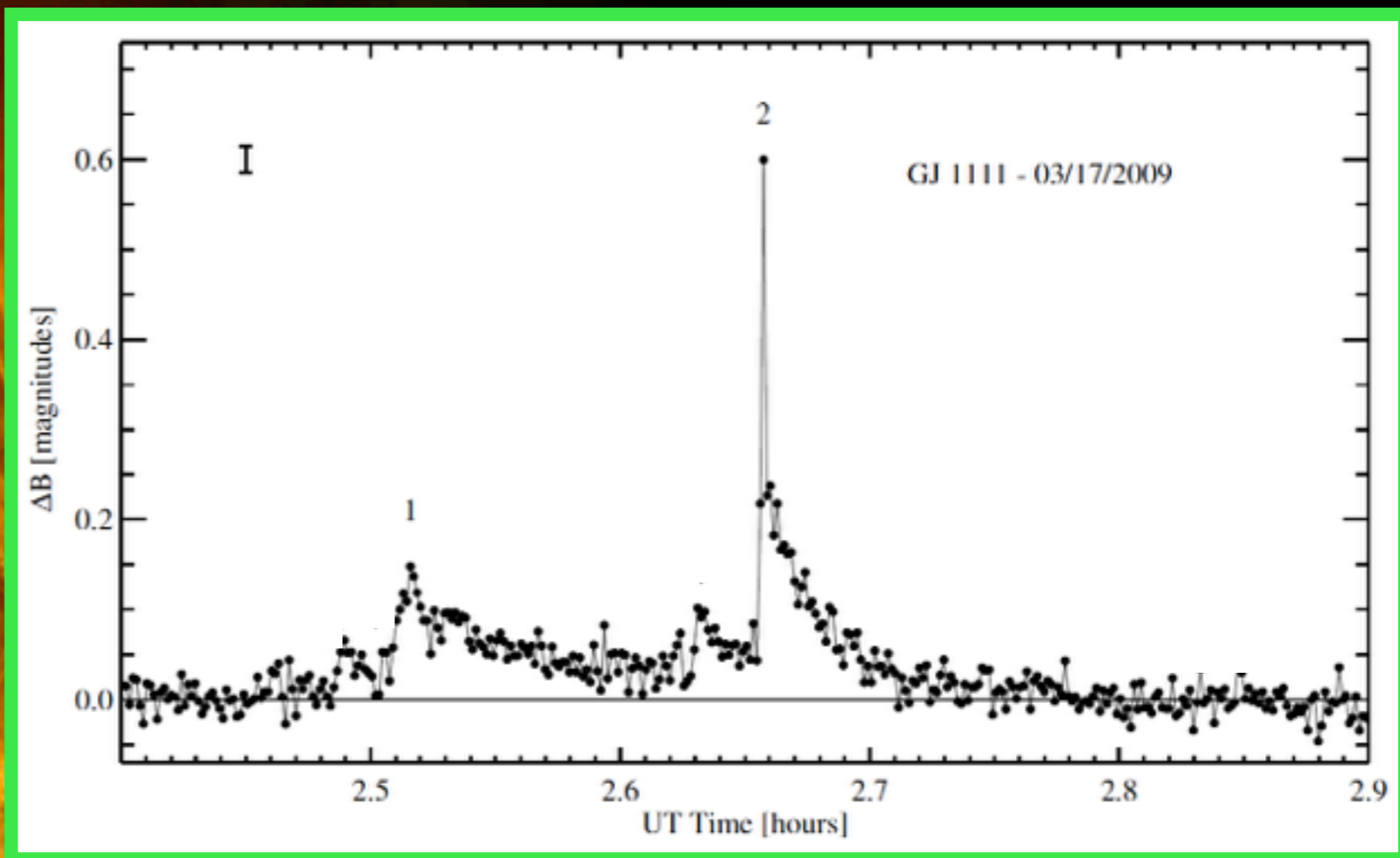
Ha emission



M dwarfs: West+ (2011); Schmidt+ (2014, in prep.)

L dwarfs: Kirkpatrick+ (1999, 2000); Reiners+ (2008); Schmidt+ (2014, in prep.); more

flares



Hilton (2011)

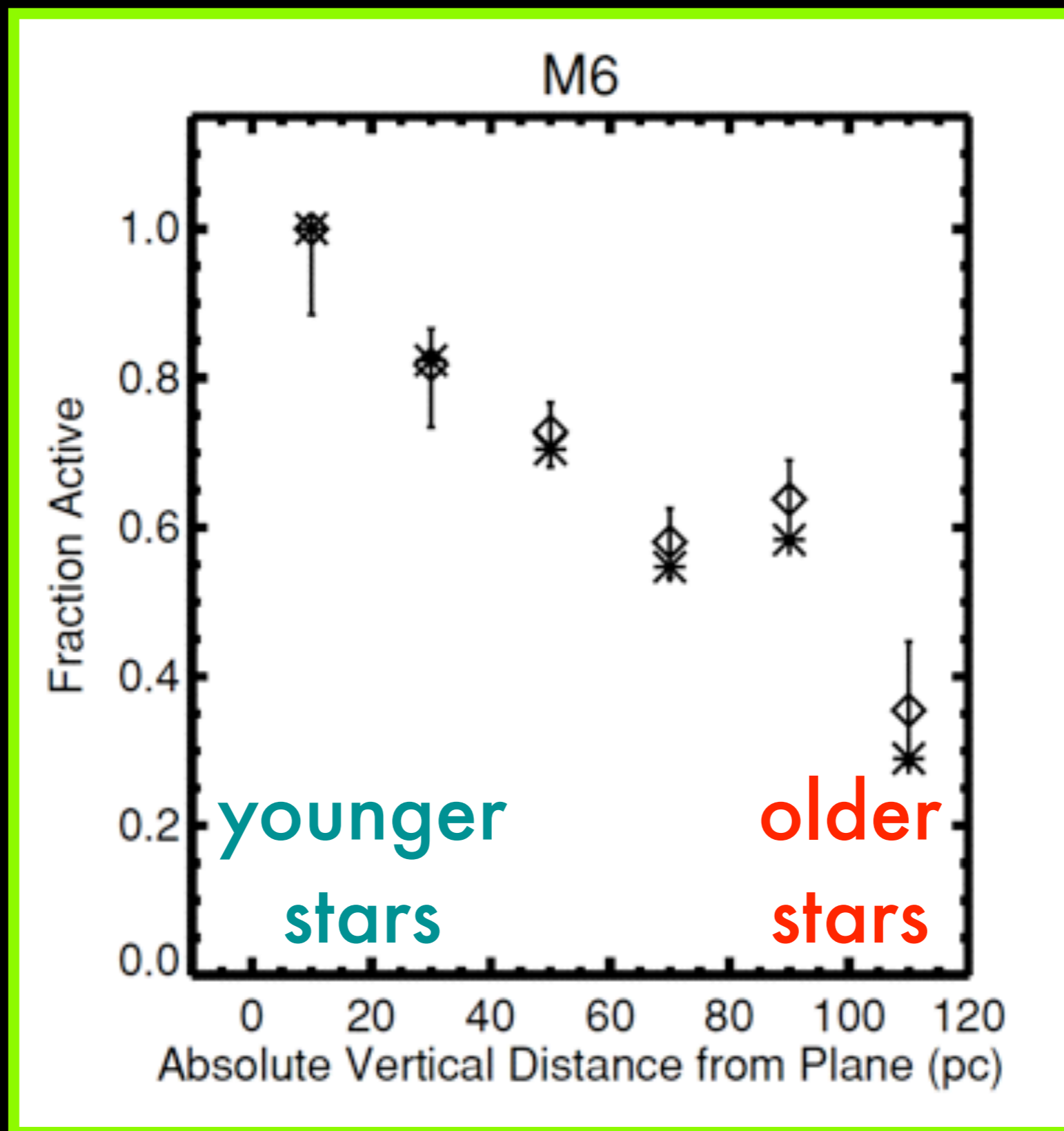
Activity+age from H α emission

Flares+age

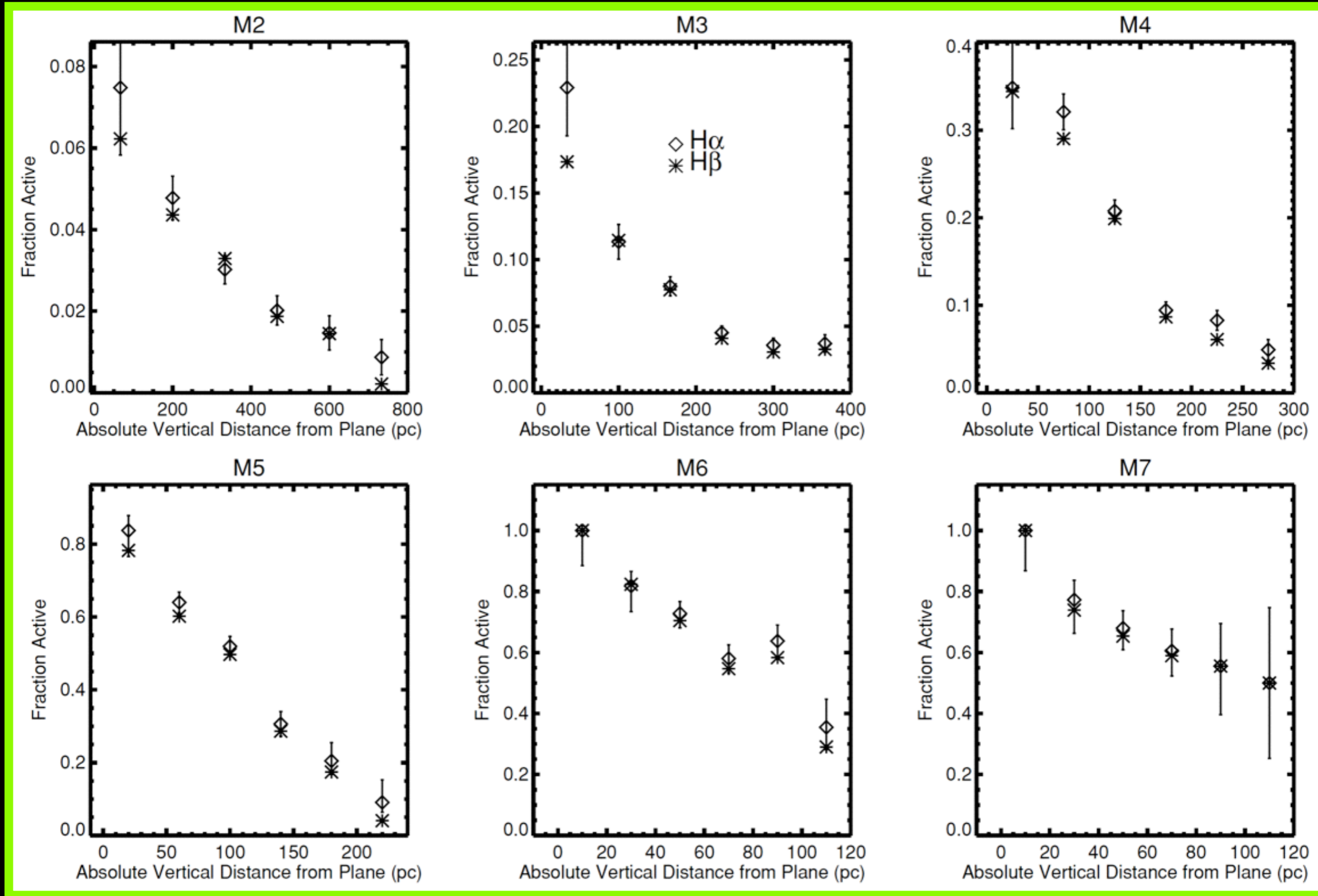
Estimating ΔG

of Gaia flares to expect

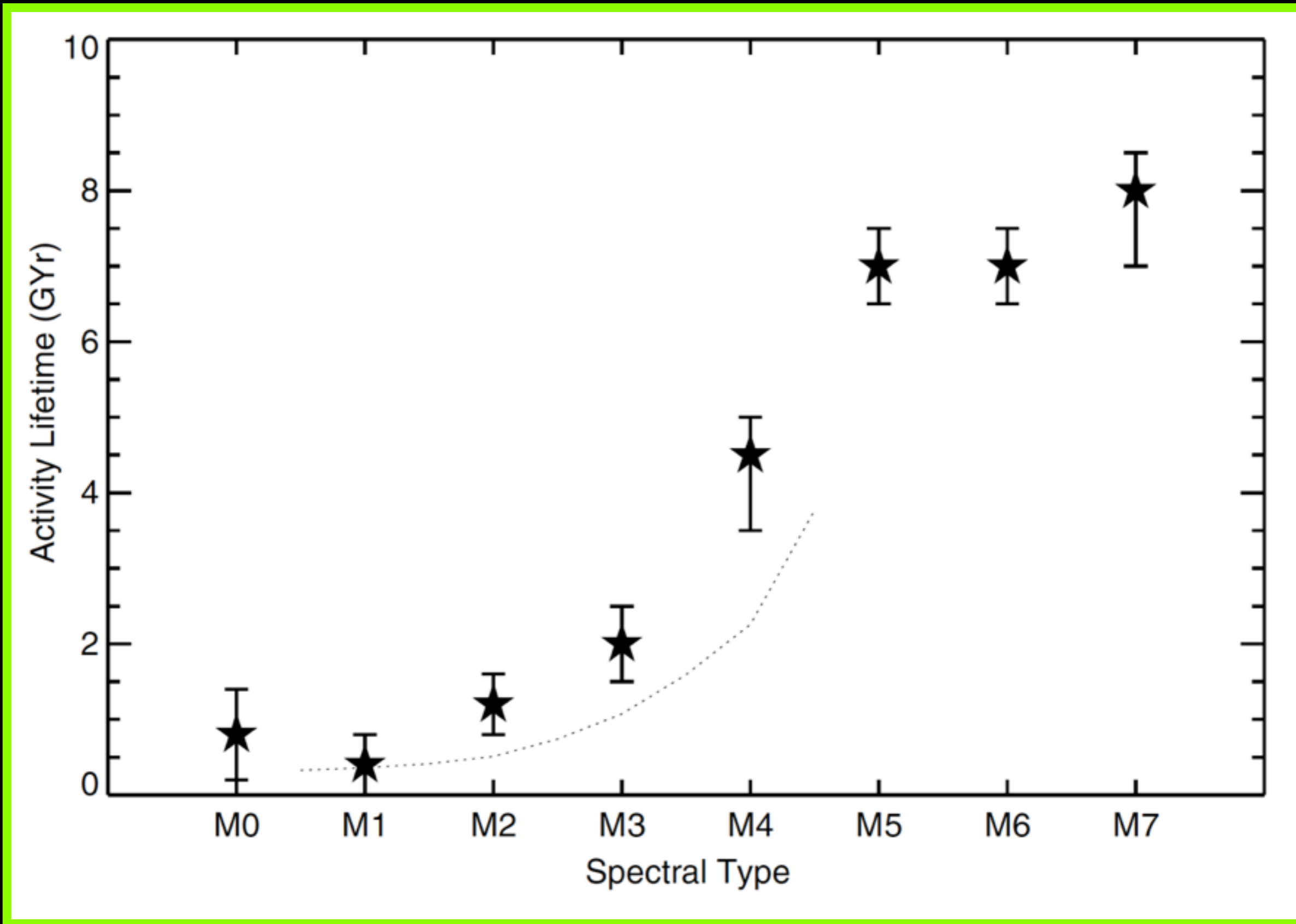
M dwarf H α emission lifetimes



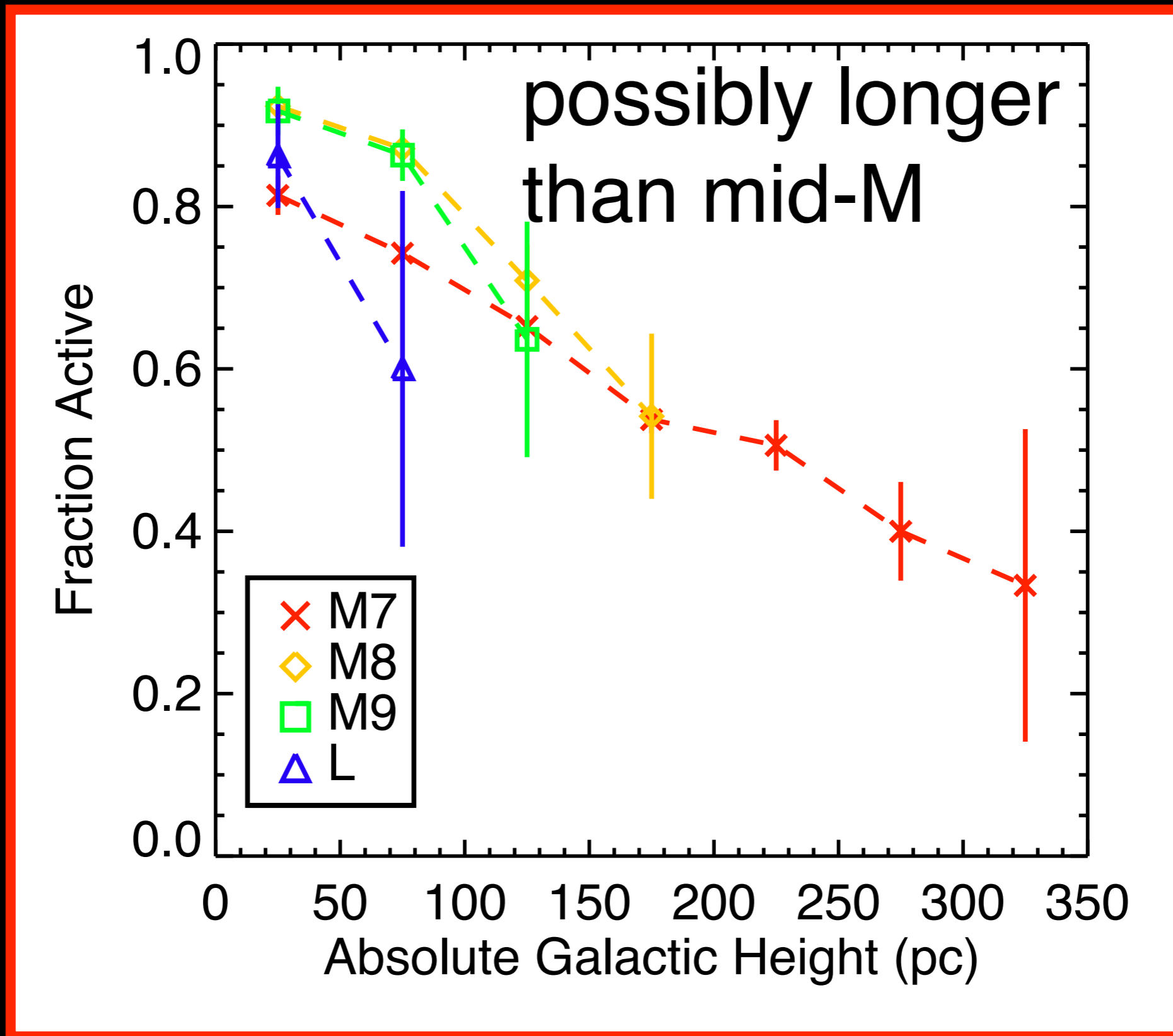
M dwarf H α emission lifetimes



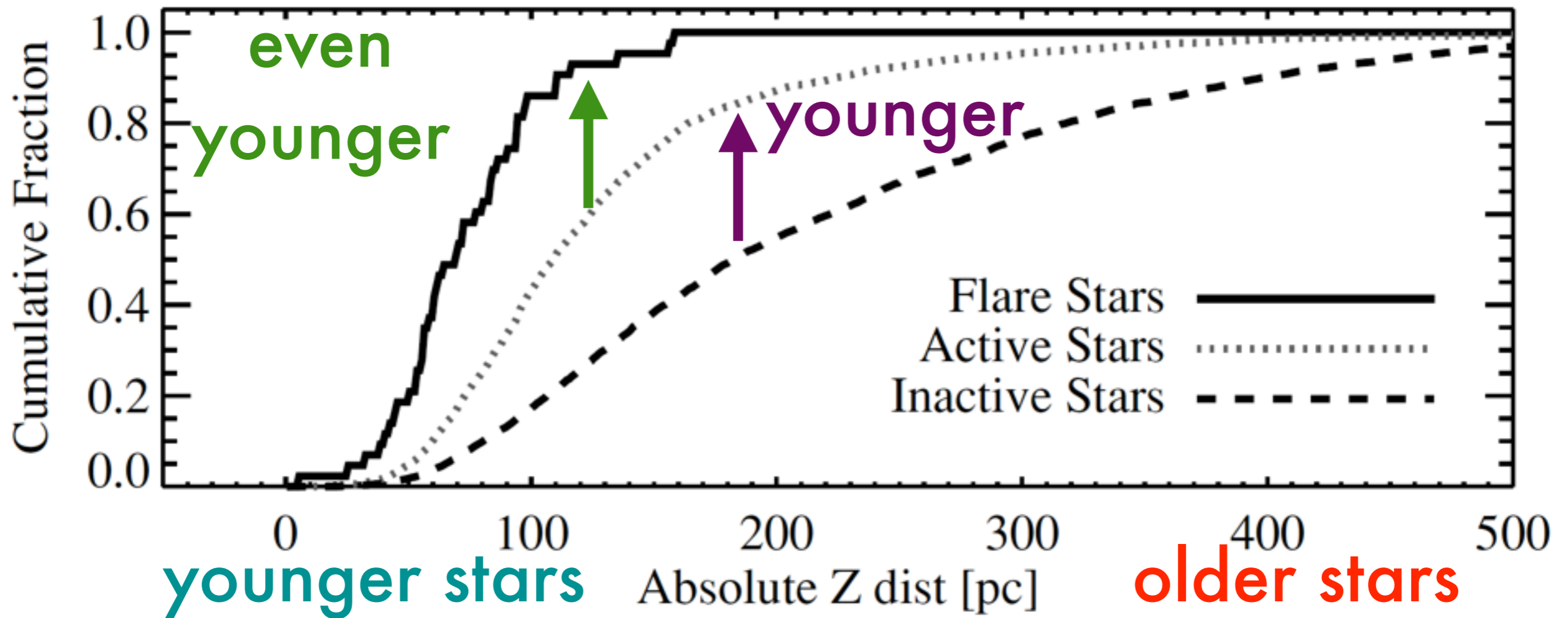
M dwarf H α emission lifetimes

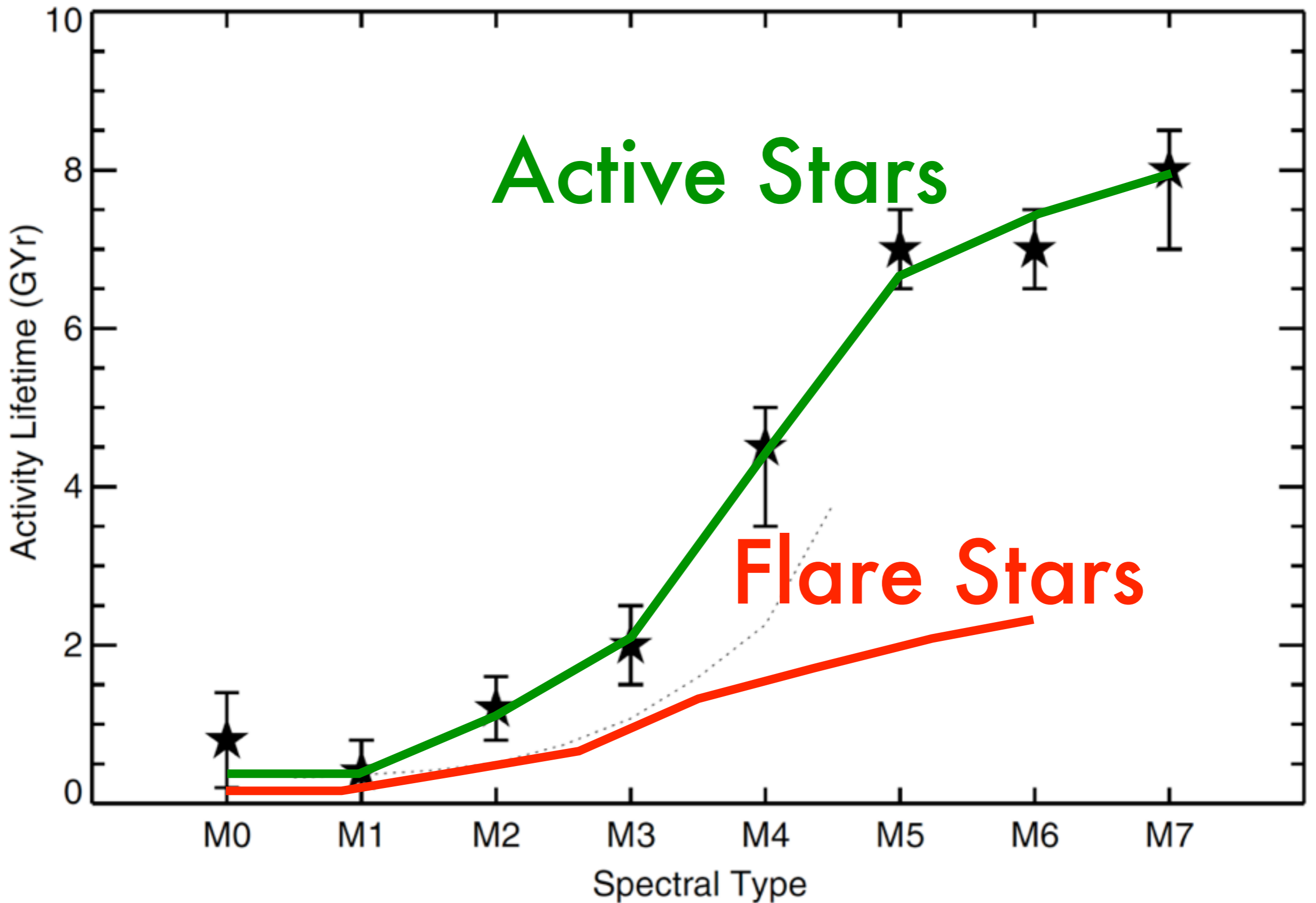


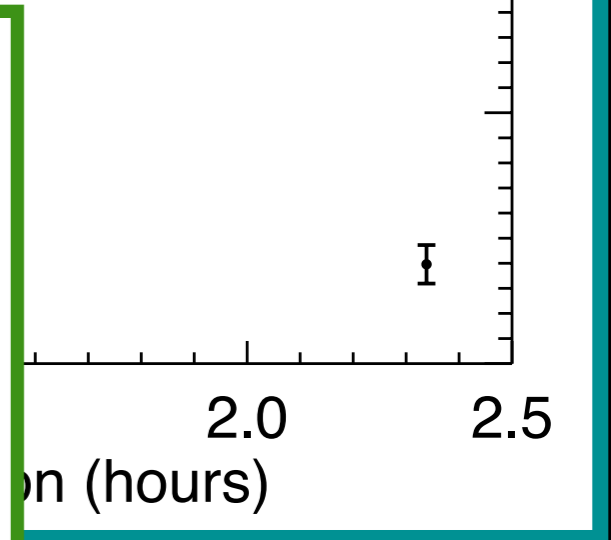
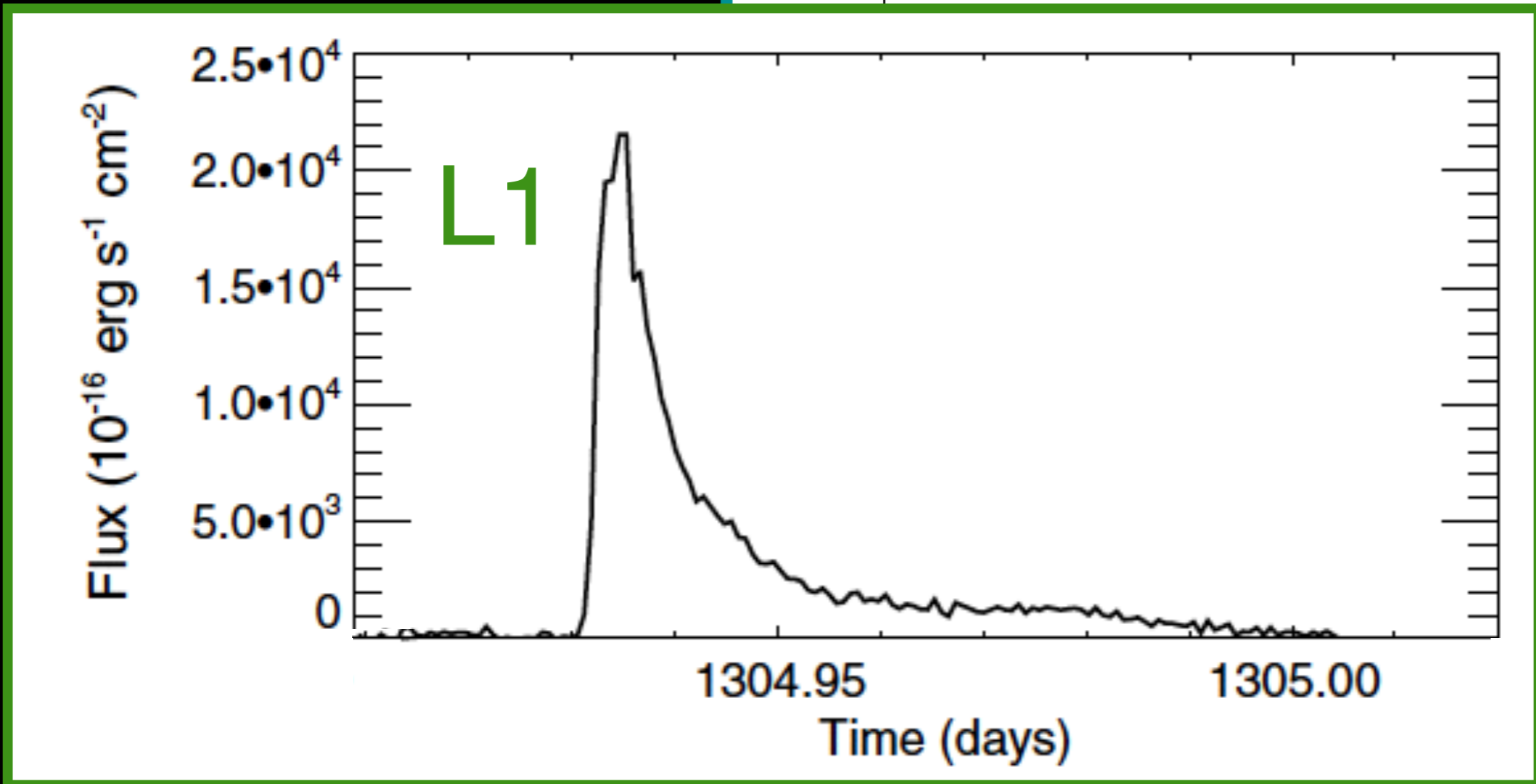
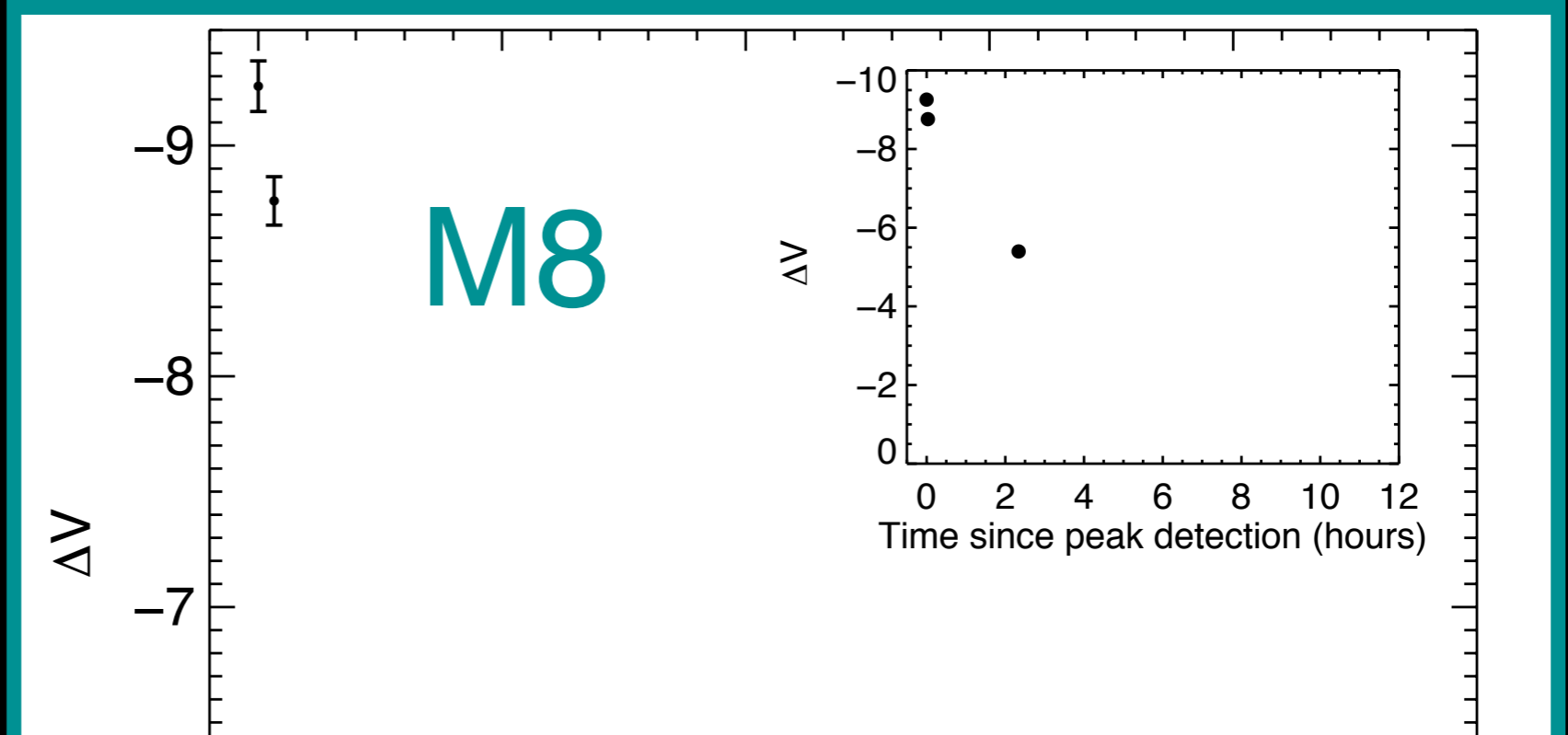
UCD Ha emission lifetimes?



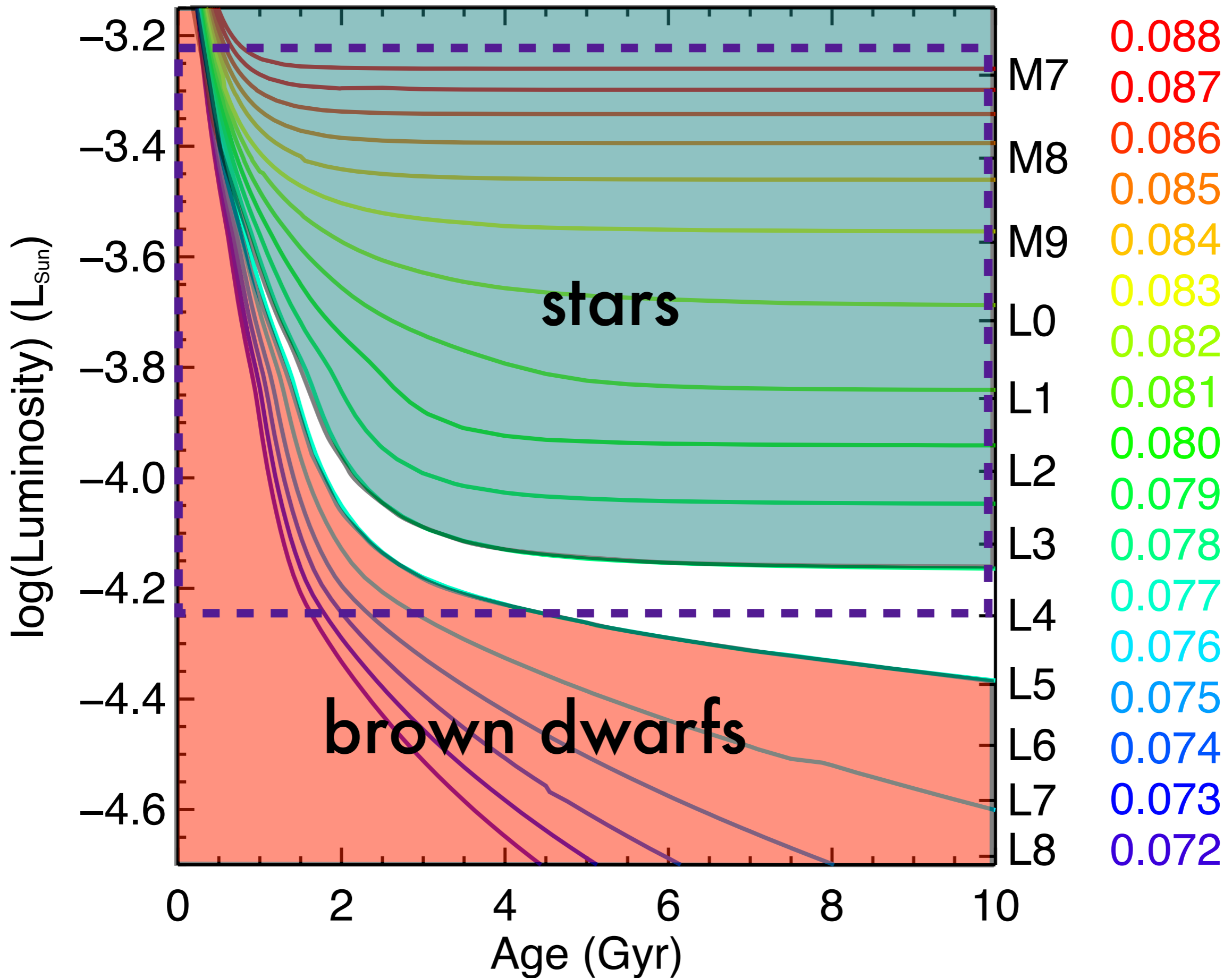
Ages of Flare Stars

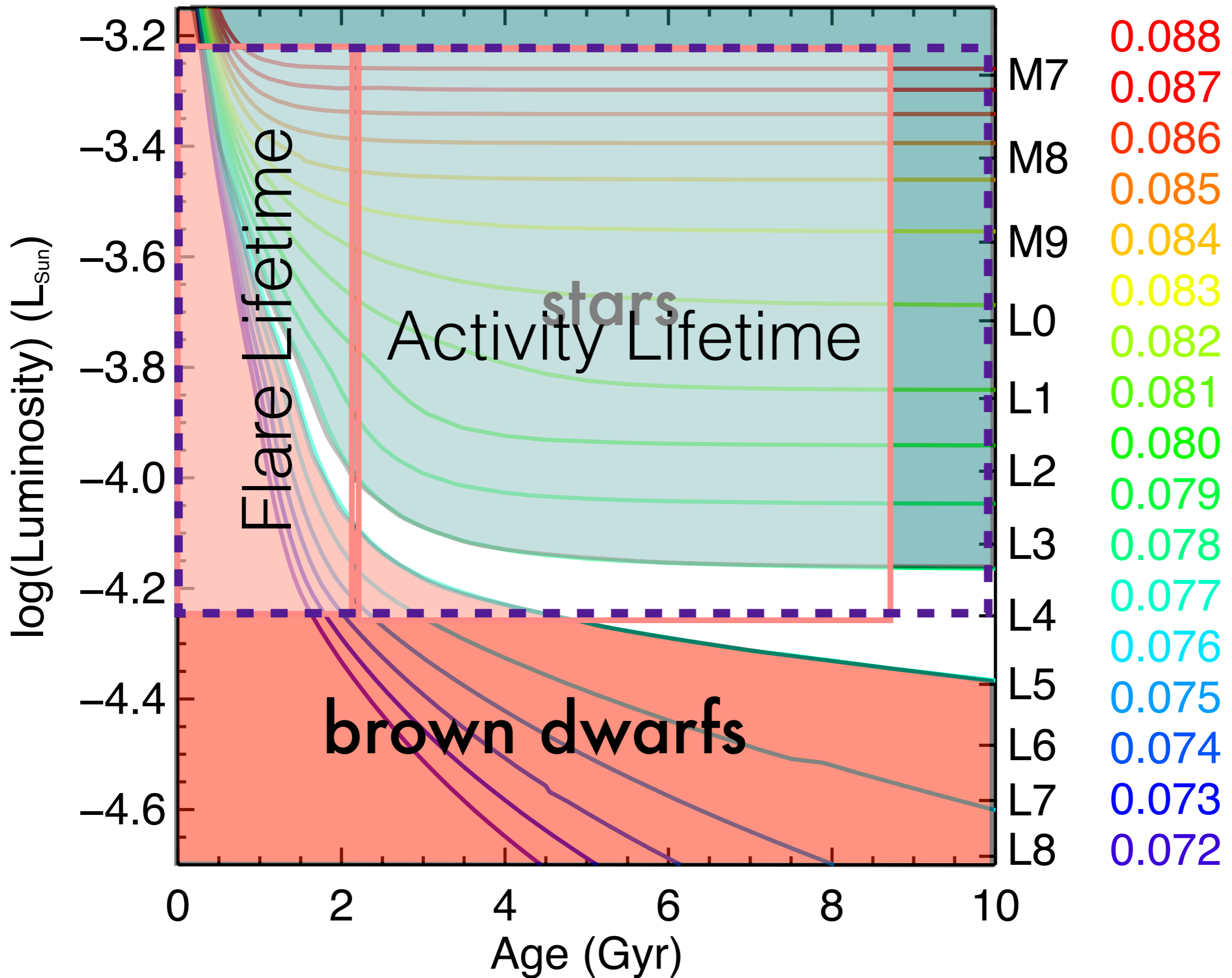






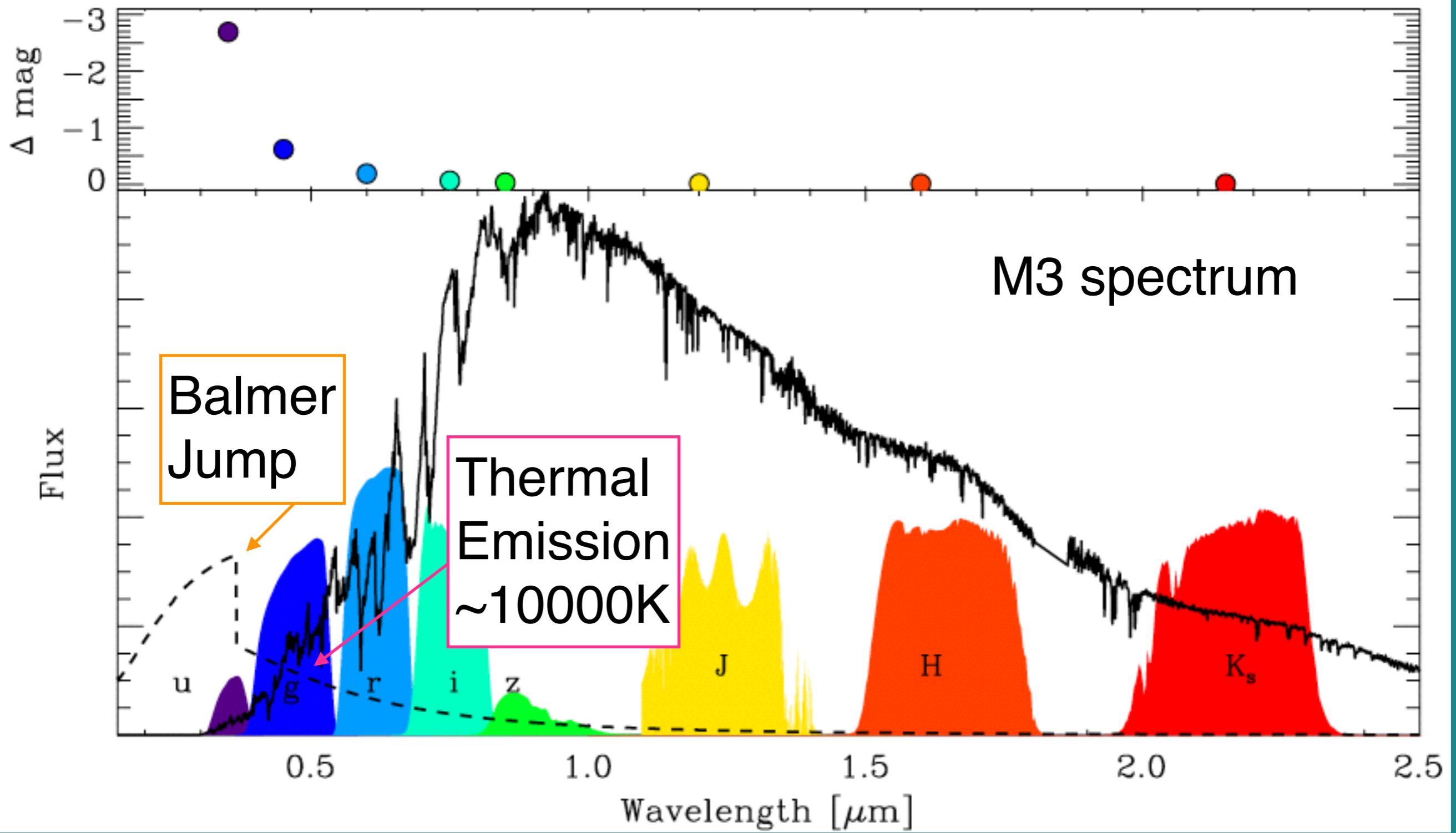
Flares could indicate
ages of 1-3 Gyr for
ultracool dwarfs

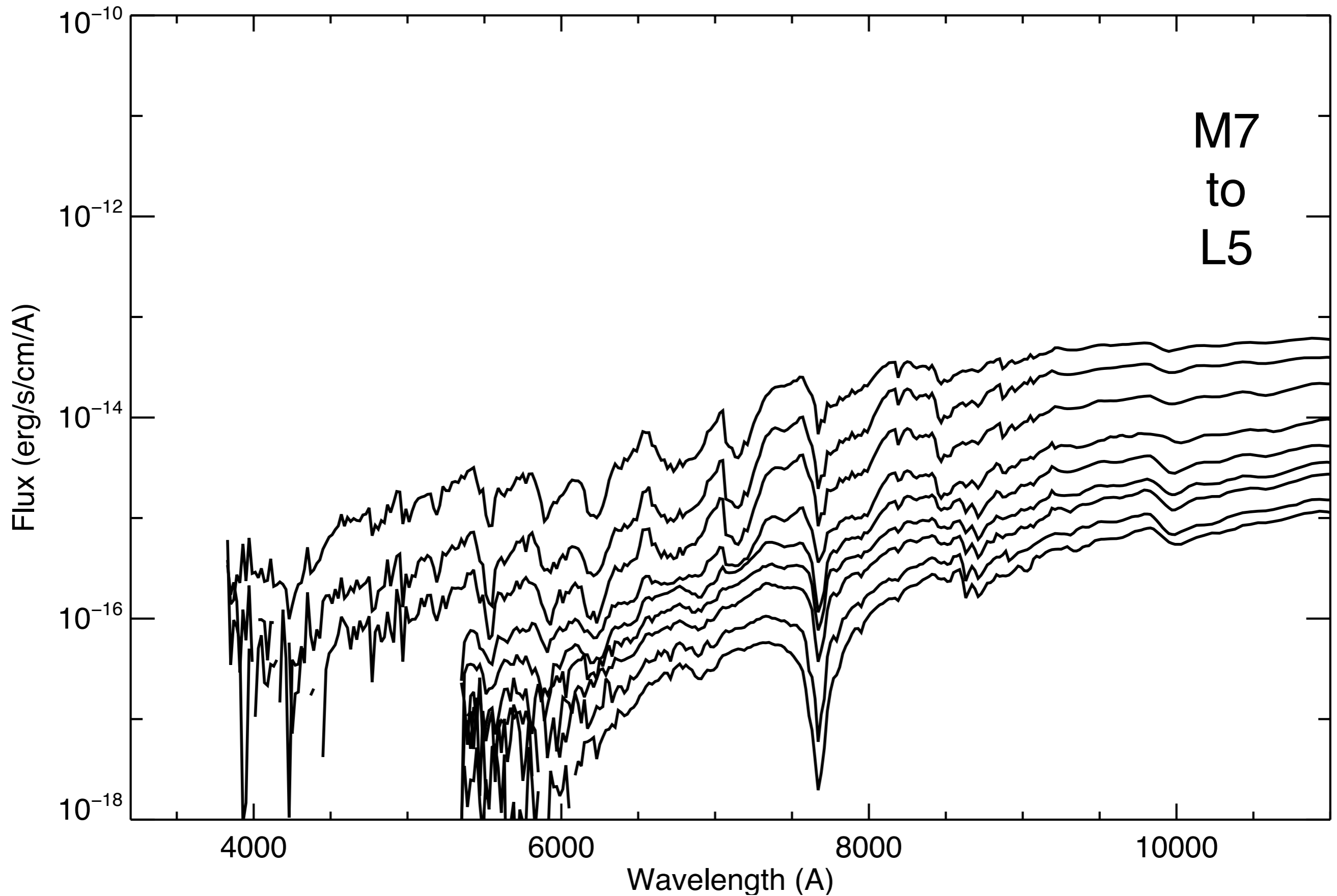


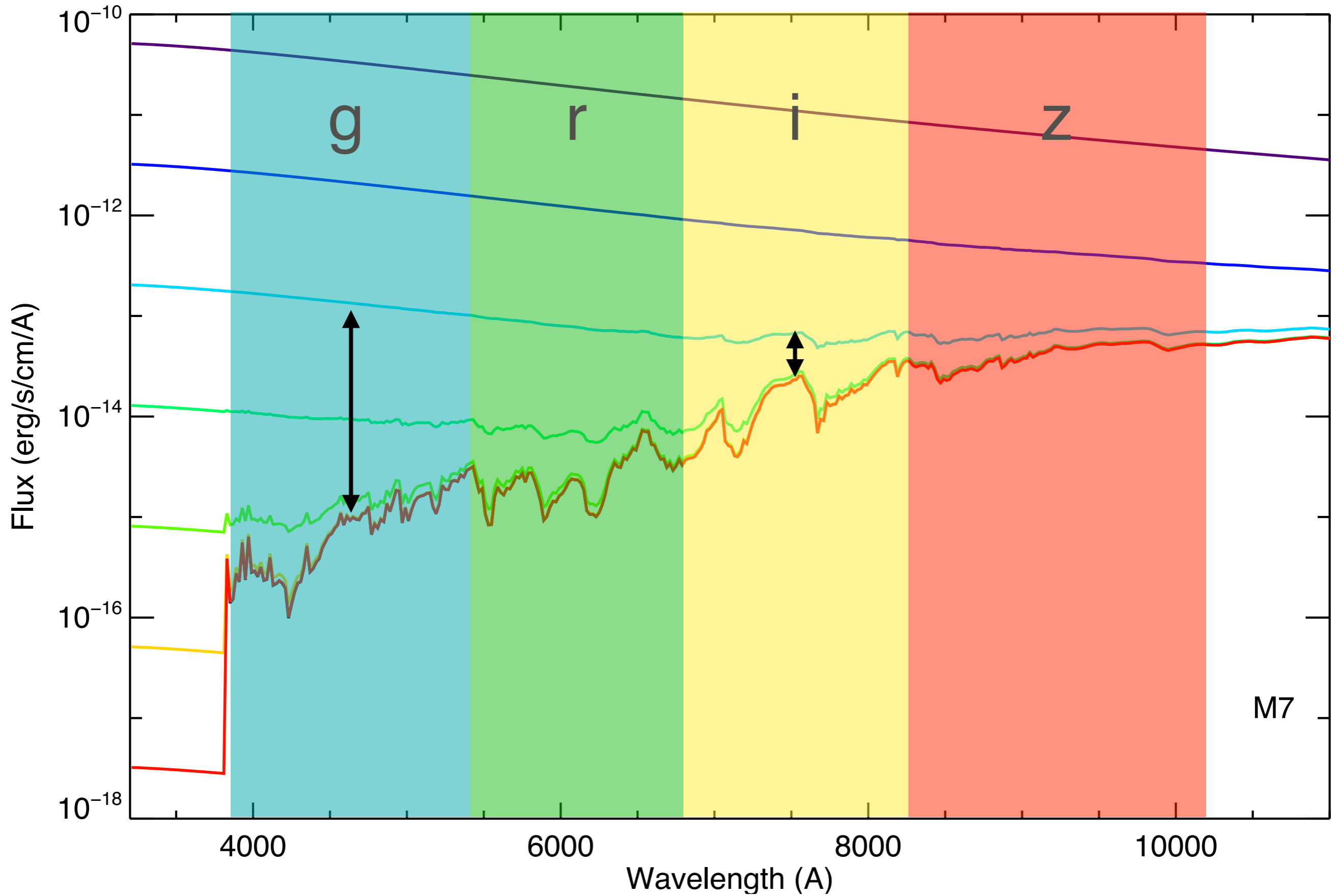


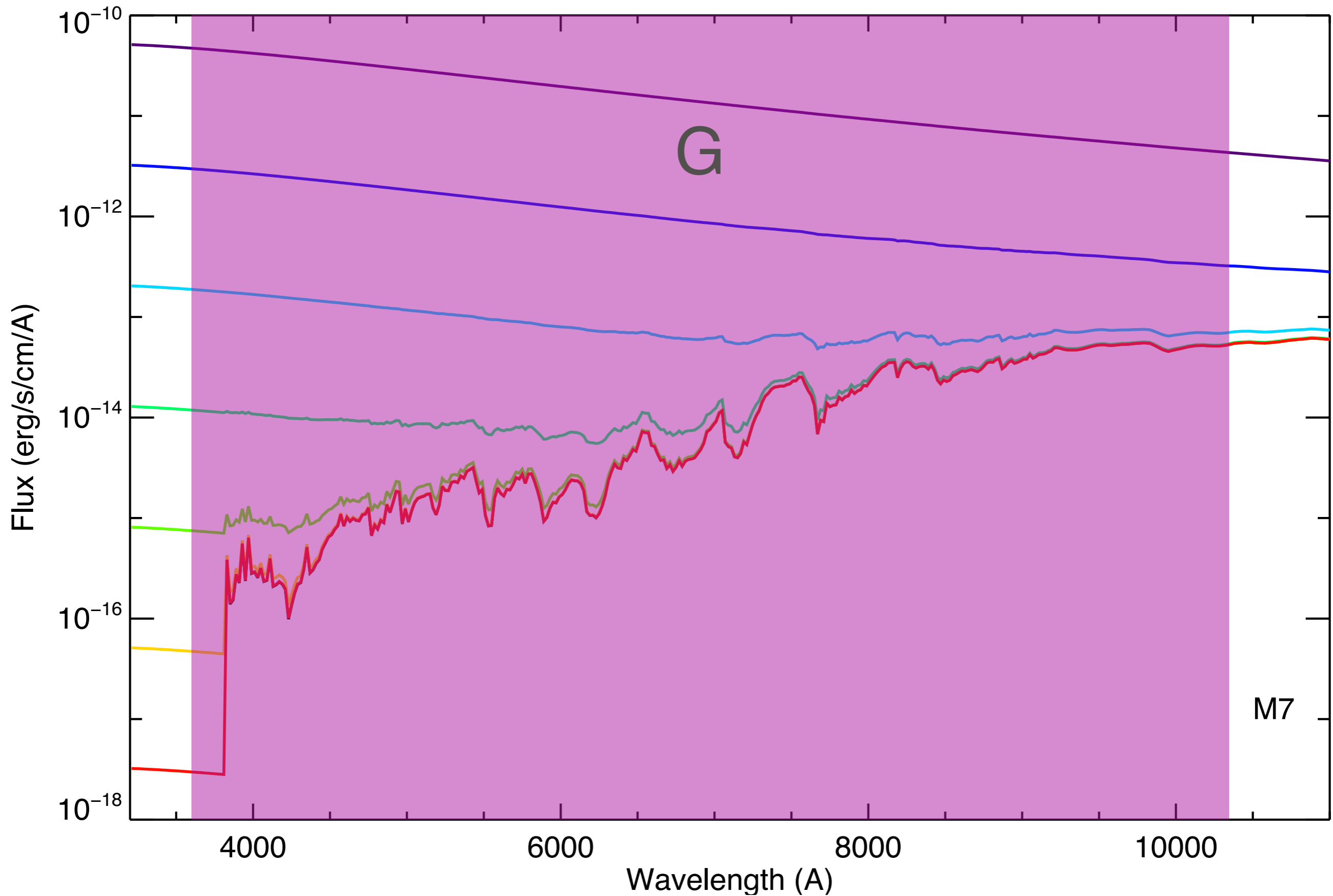
Estimating ΔG

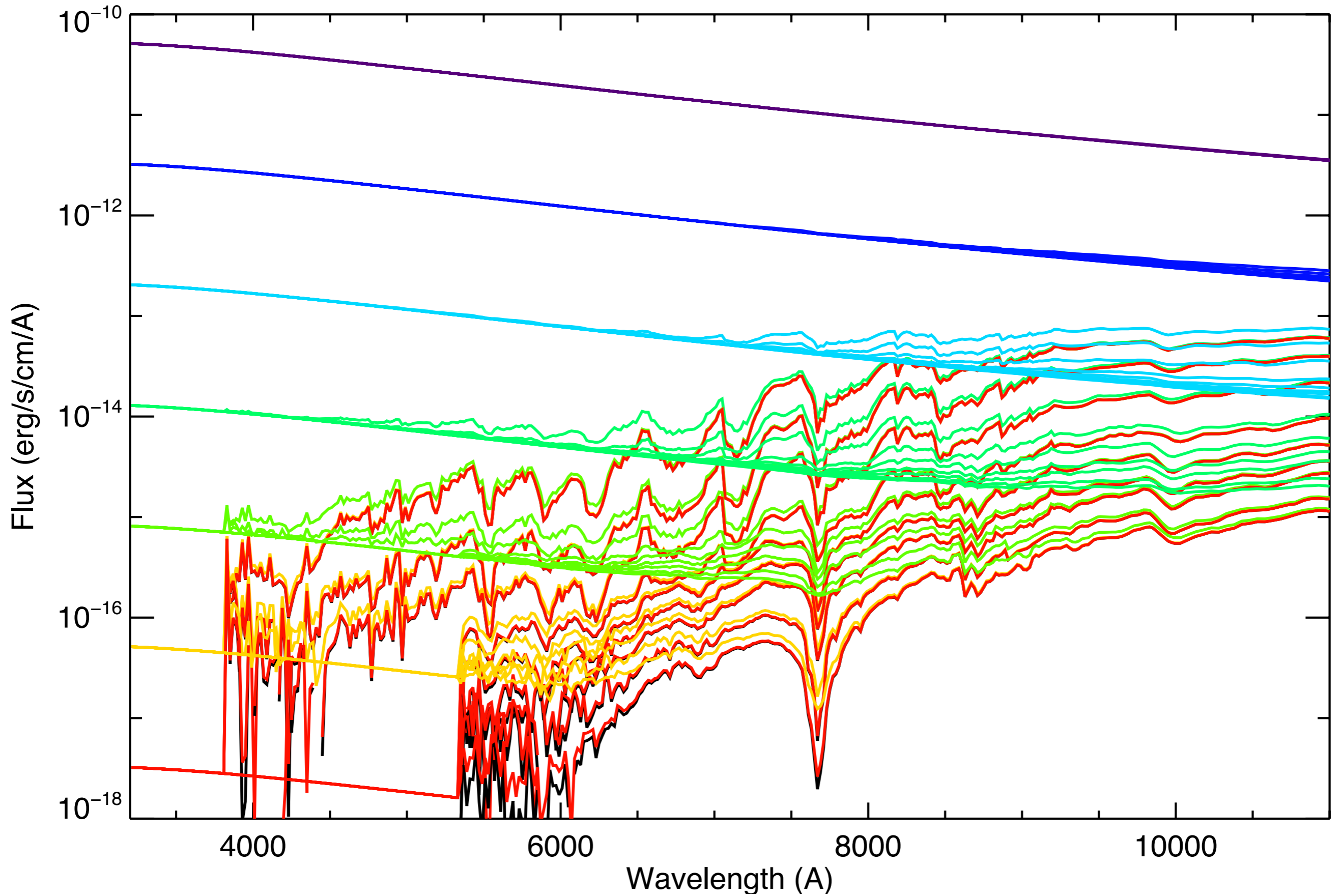
of Gaia flares to expect

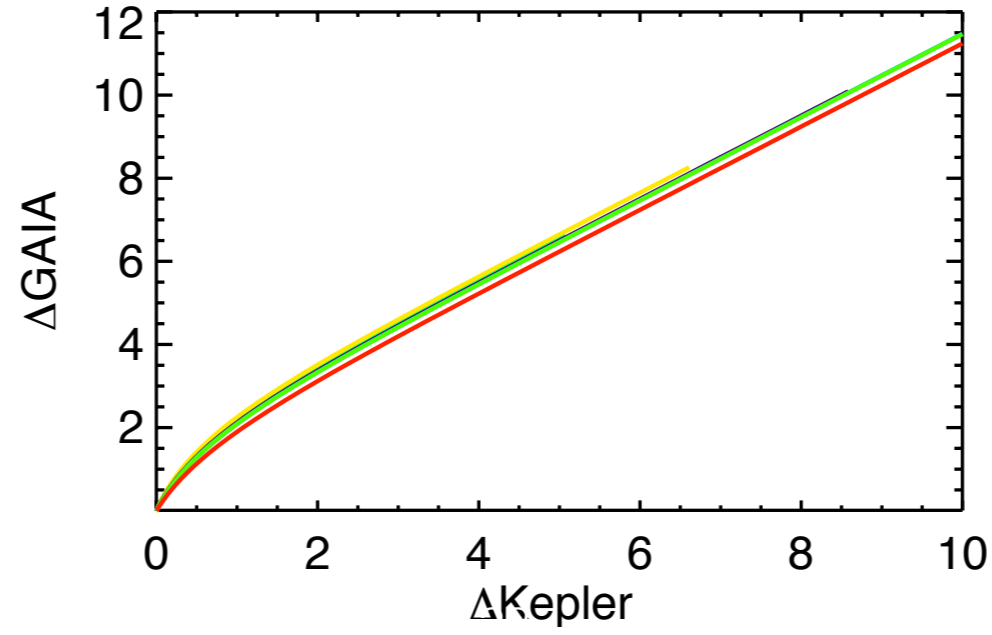
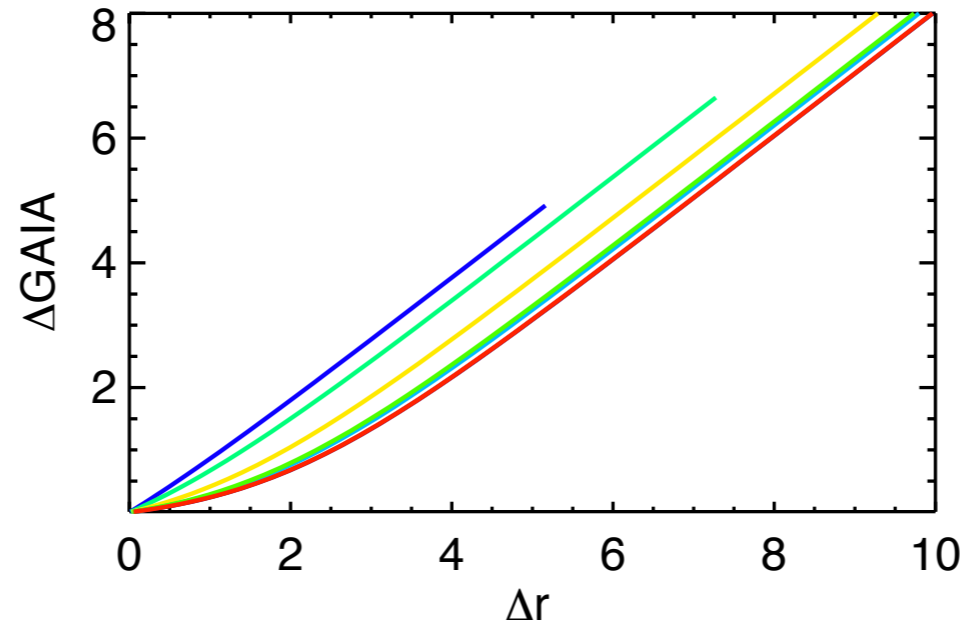
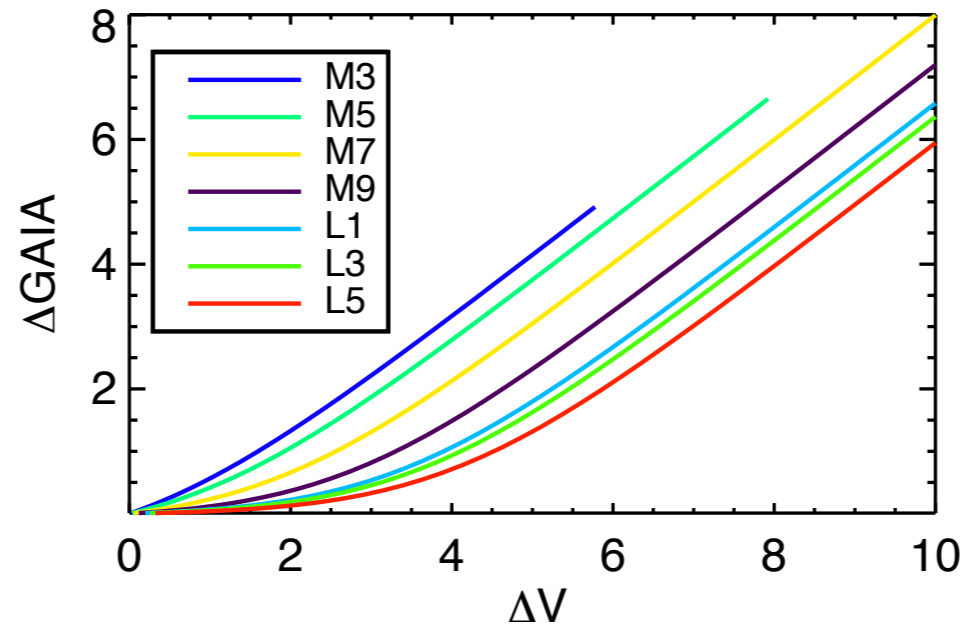


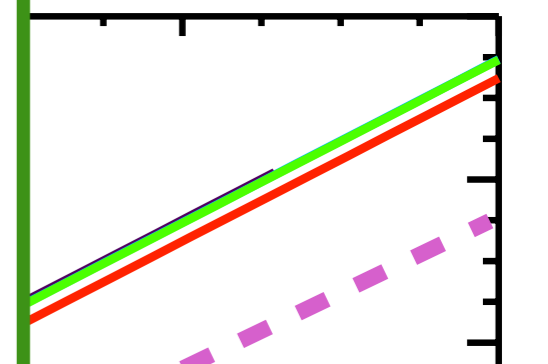
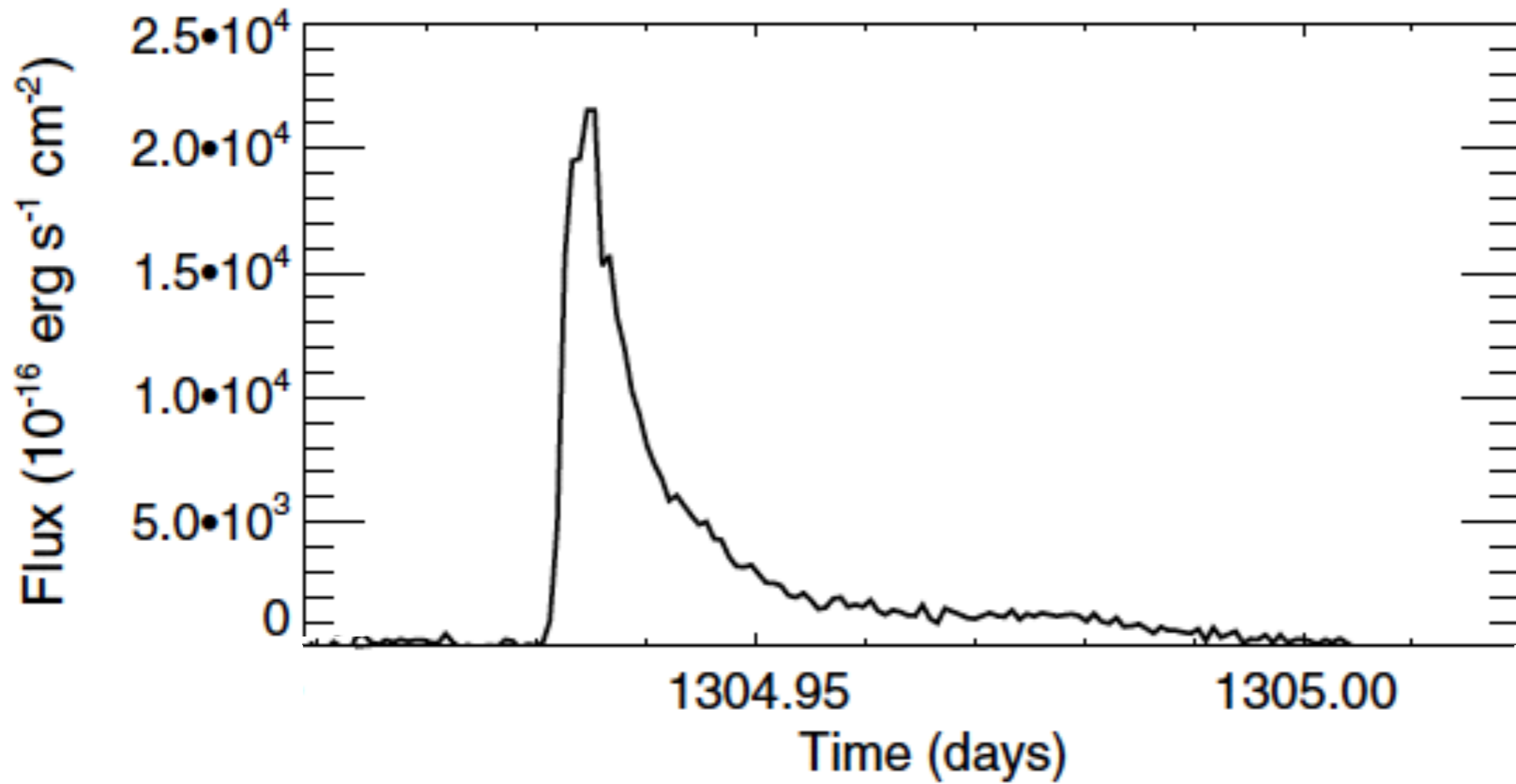




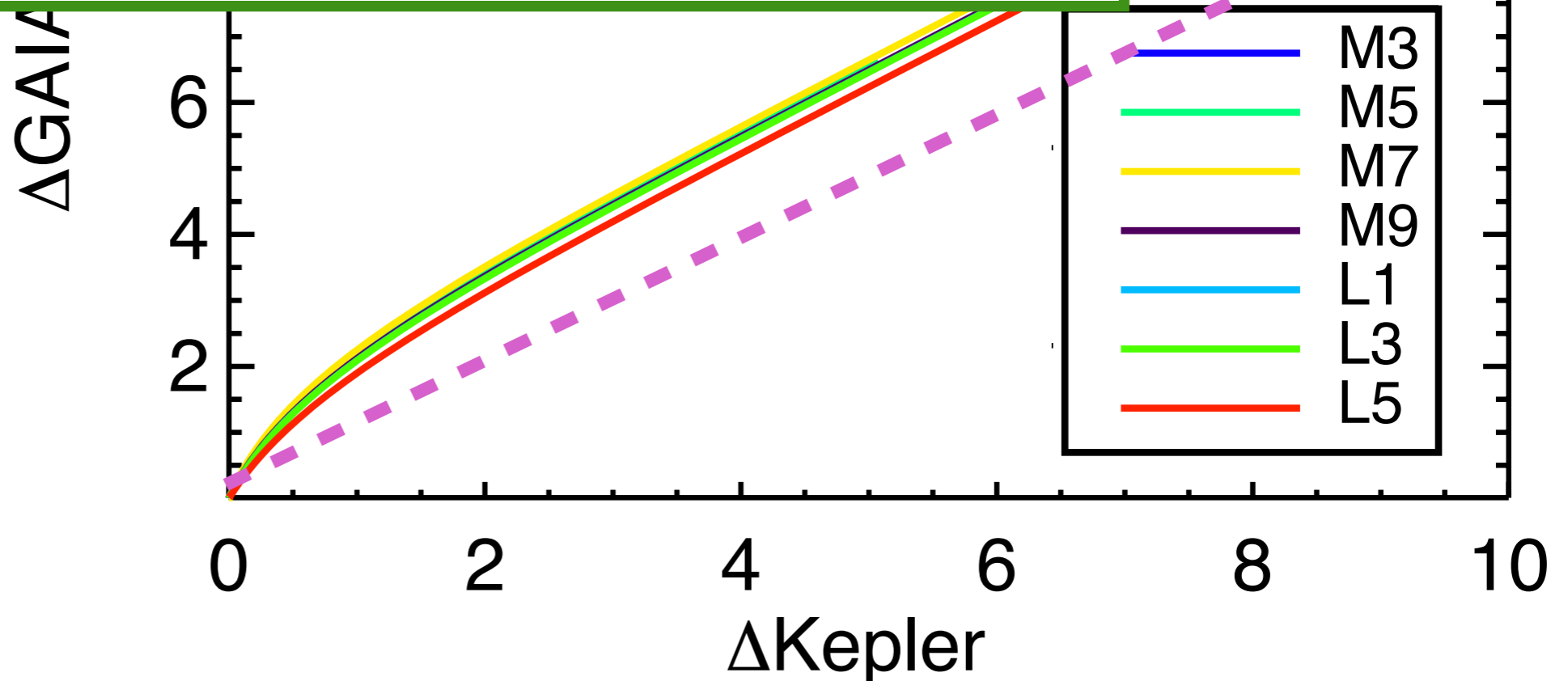


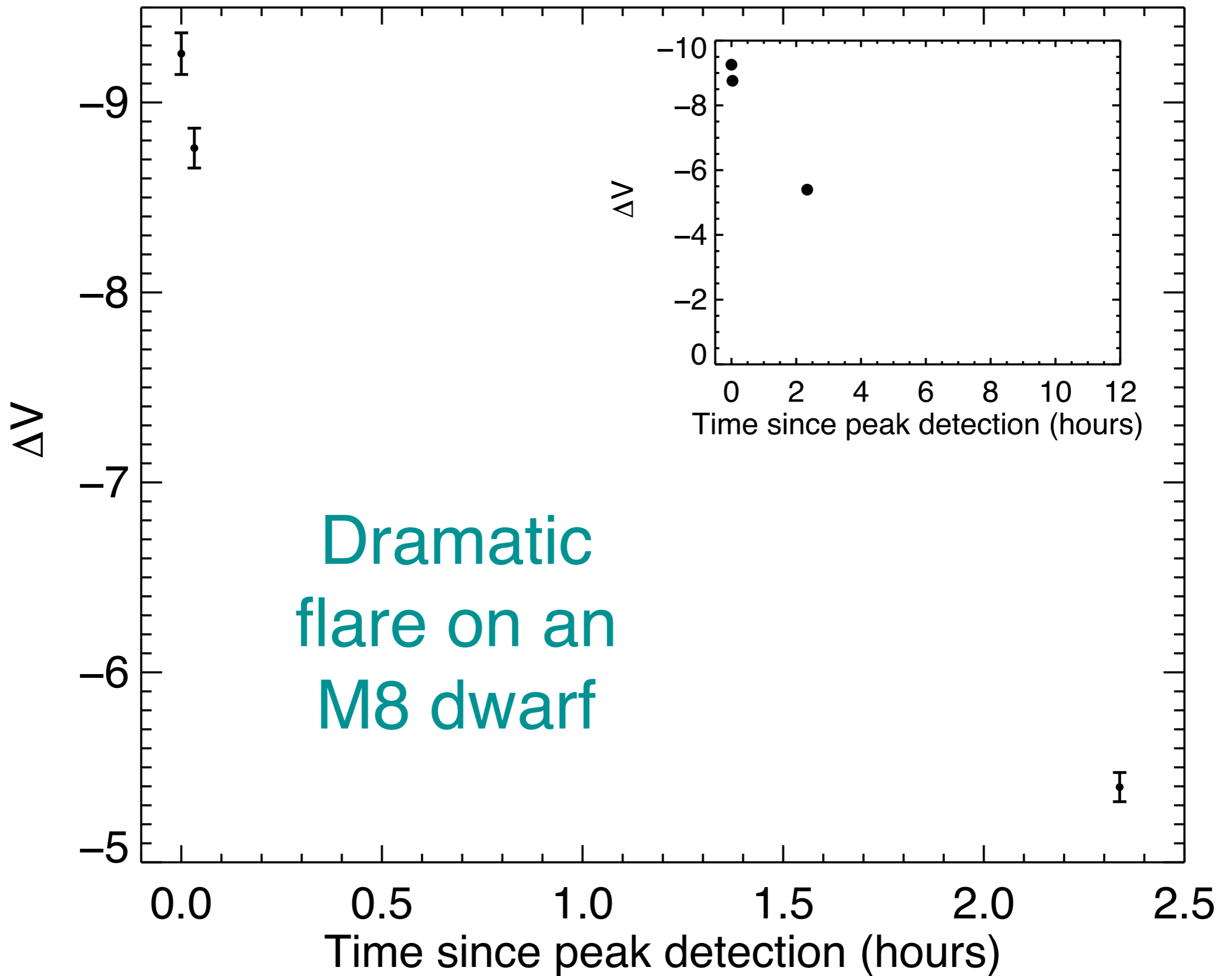


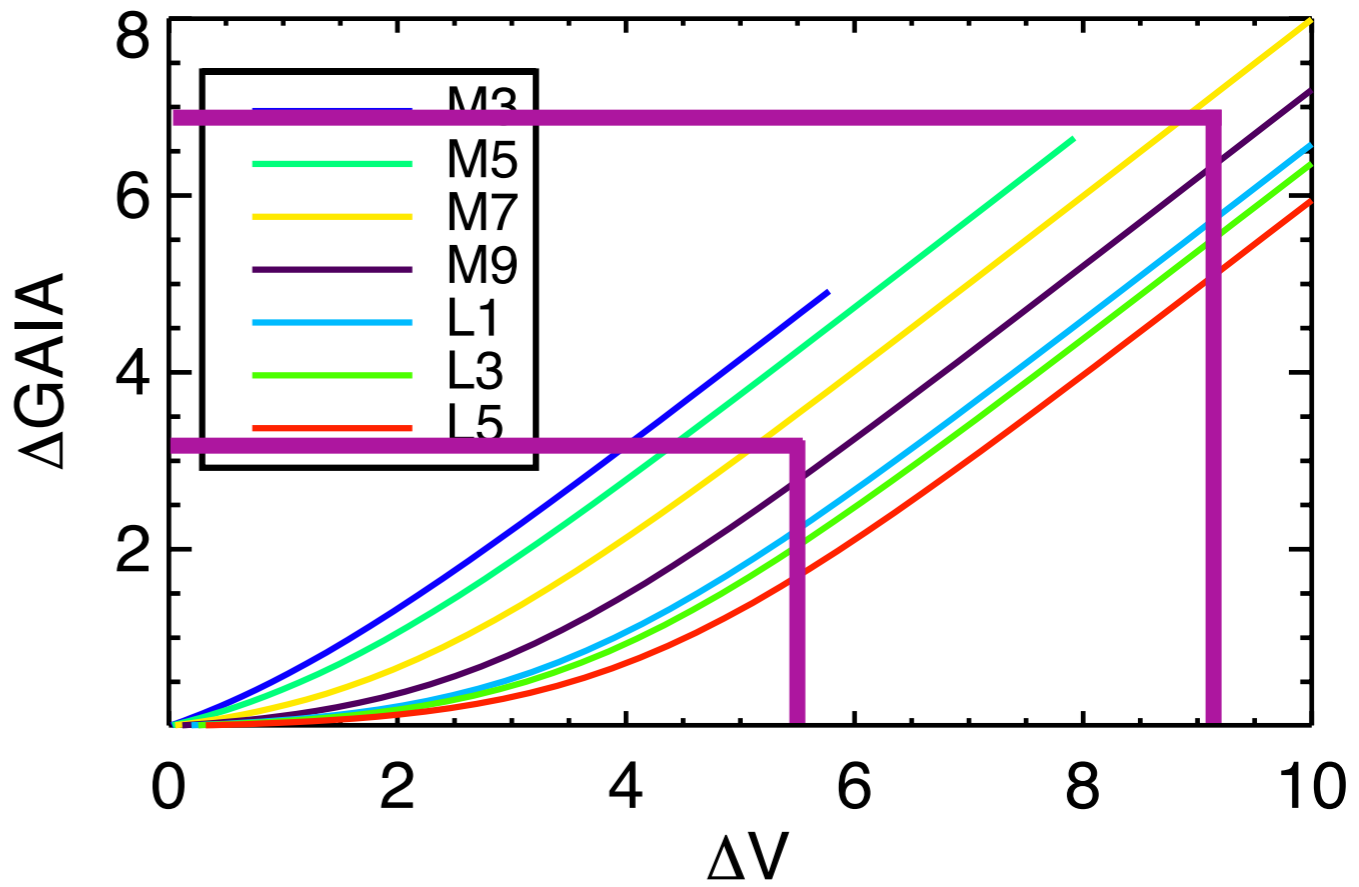
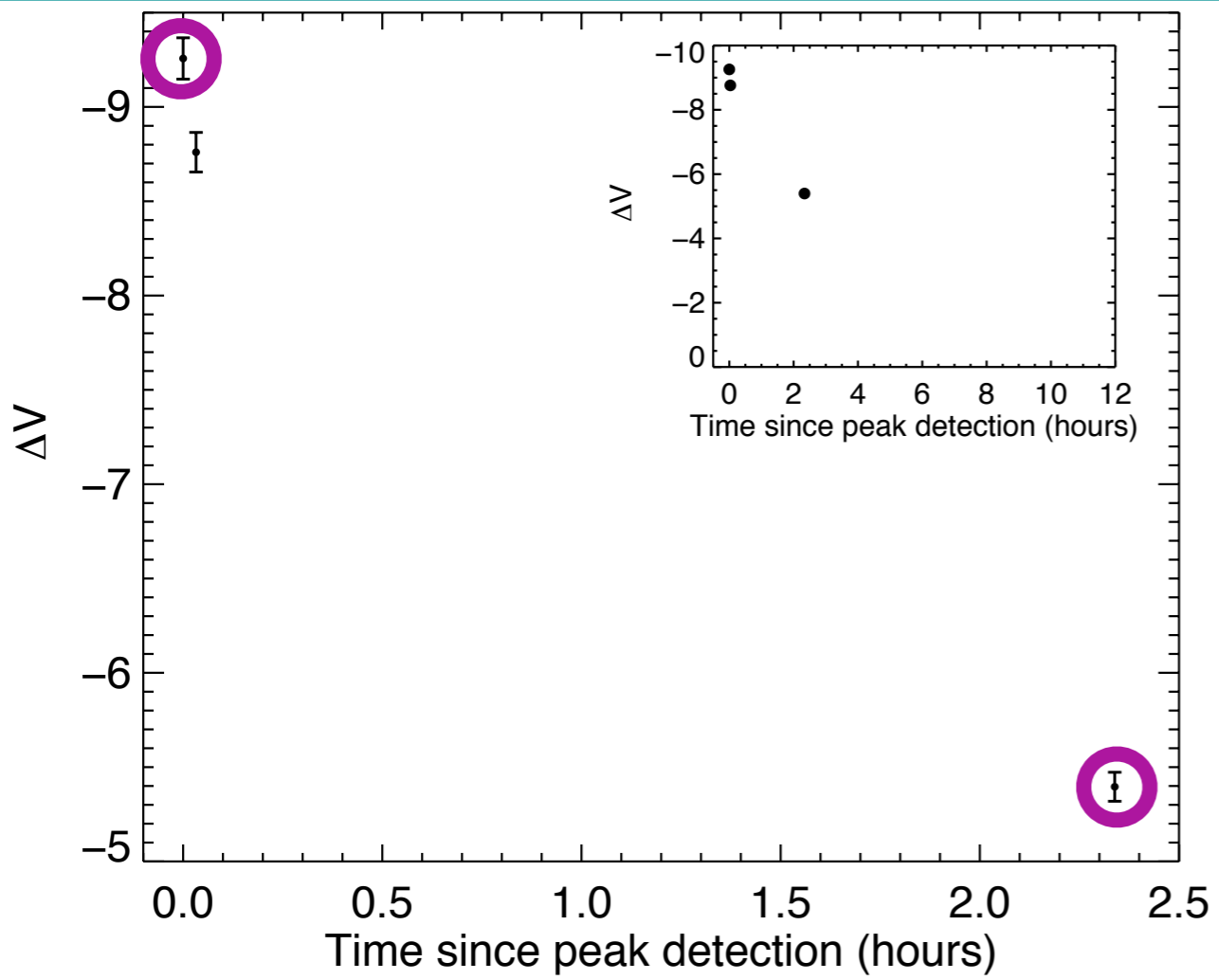




Gizis+ (2013)

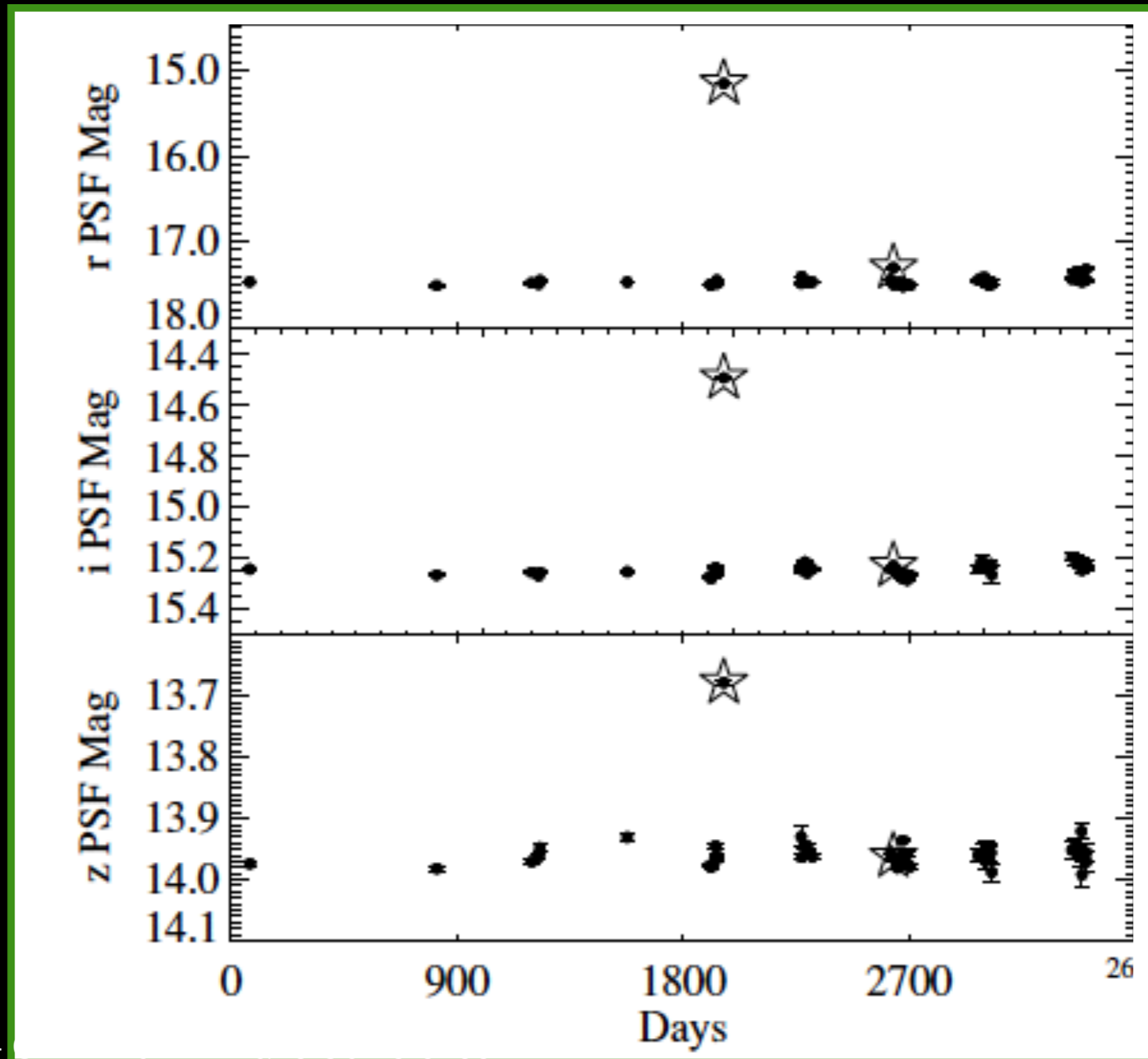






How many flares in Gaia?

scale from Kowalski+ (2009) Stripe82 M dwarf flare rate



But how many?

scale from Kowalski+ (2009) Stripe82 M0-M6 dwarf flare rate

Magnitude Limit	Flare Strength	Flare Rate
$u < 22$	$\Delta u > 0.7$	1.2 hr
$u < 22$	$\Delta u > 5$	0.0055 hr
$r < 18.5$	$\Delta r > 1$	0.0055 hr
$G < 23$	$\Delta G > 0.3$	0.0055 hr
$G < 20$	$\Delta G > 0.3$	0.0014 hr

How many flares in Gaia?

$$\begin{aligned} &0.0014 \text{ hr}^{-1} \text{ deg}^{-2} \\ &\quad \times 70 \text{ visits} \\ &\quad \times 2 \text{ arms} \times 9 \text{ ccids} \\ &\quad \times \sim 4.4 \text{ seconds} \\ &\quad \times 41253 \text{ deg}^2 \\ &\quad \sim \\ &300,000 \end{aligned}$$

How many flares in Gaia?

Gaia could see $\sim 300,000$ flares of at least $\Delta G > 0.3$ on M0-M6 dwarfs

If flares are as common on M7-L5 dwarfs, then we'd expect ~ 300

Finding an Age/Activity Relationship

- **Age:** Estimate age from Gaia kinematics
- **Activity:** Number and strength of flares from Gaia's multi-epoch photometry

