A New Photometric Mass Scale

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Motivation

Stellar Parameters:

- Mass
- Age (<20 Myrs)

~Degenerate: $\downarrow M_*$

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Timescales: pre-MS & T_{ff}

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Pre-MS isochrones don't fit observations!

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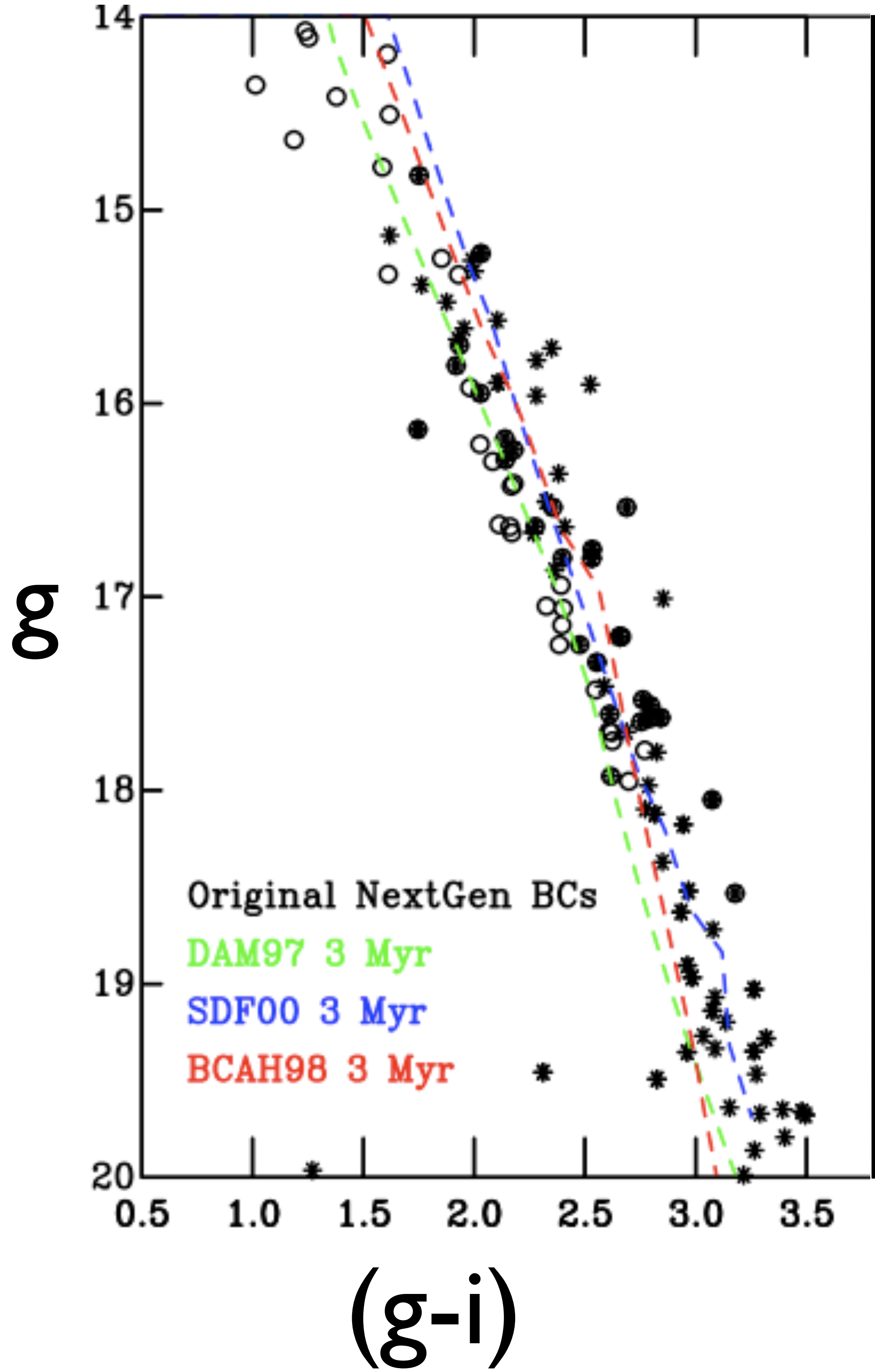

λ Ori ~3-5 Myrs

Gradient-d(Mag)/d(Col) ✘

- Age = F(Model)
- Age = F(Col)

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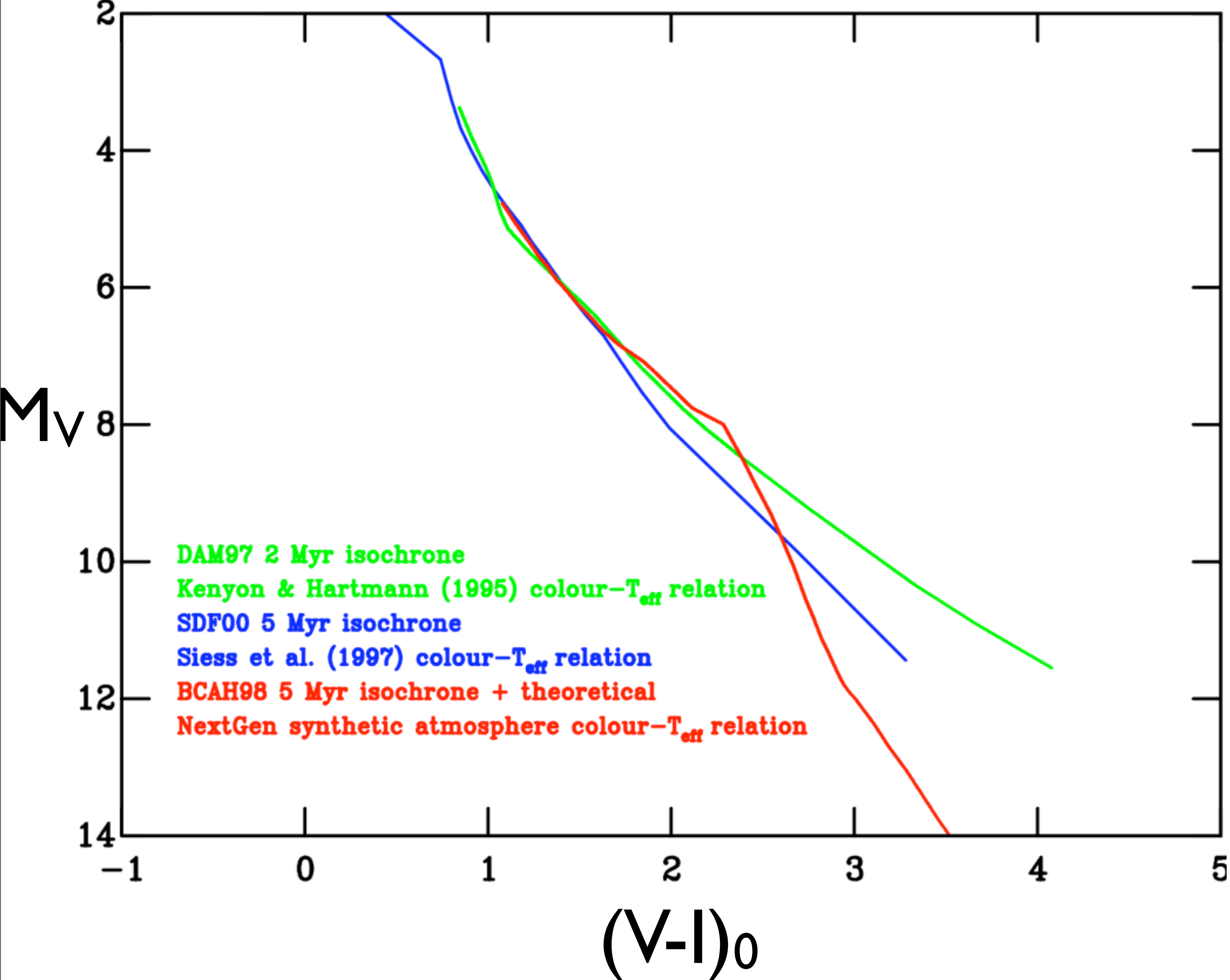

Age issue?

MS ✔

HM pre-MS ✔

pre-MS ✘

$(V-I)_0 \sim 2$

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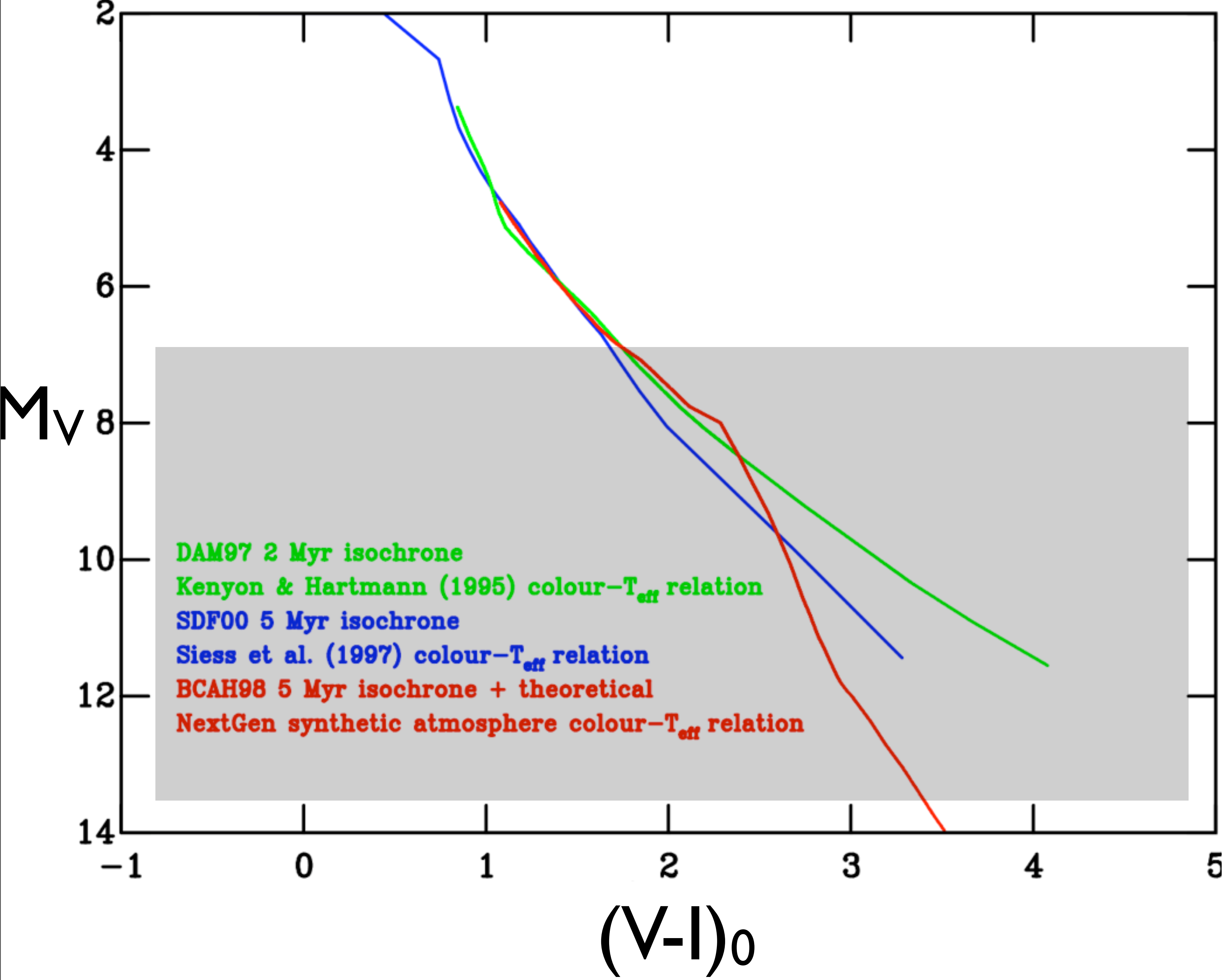

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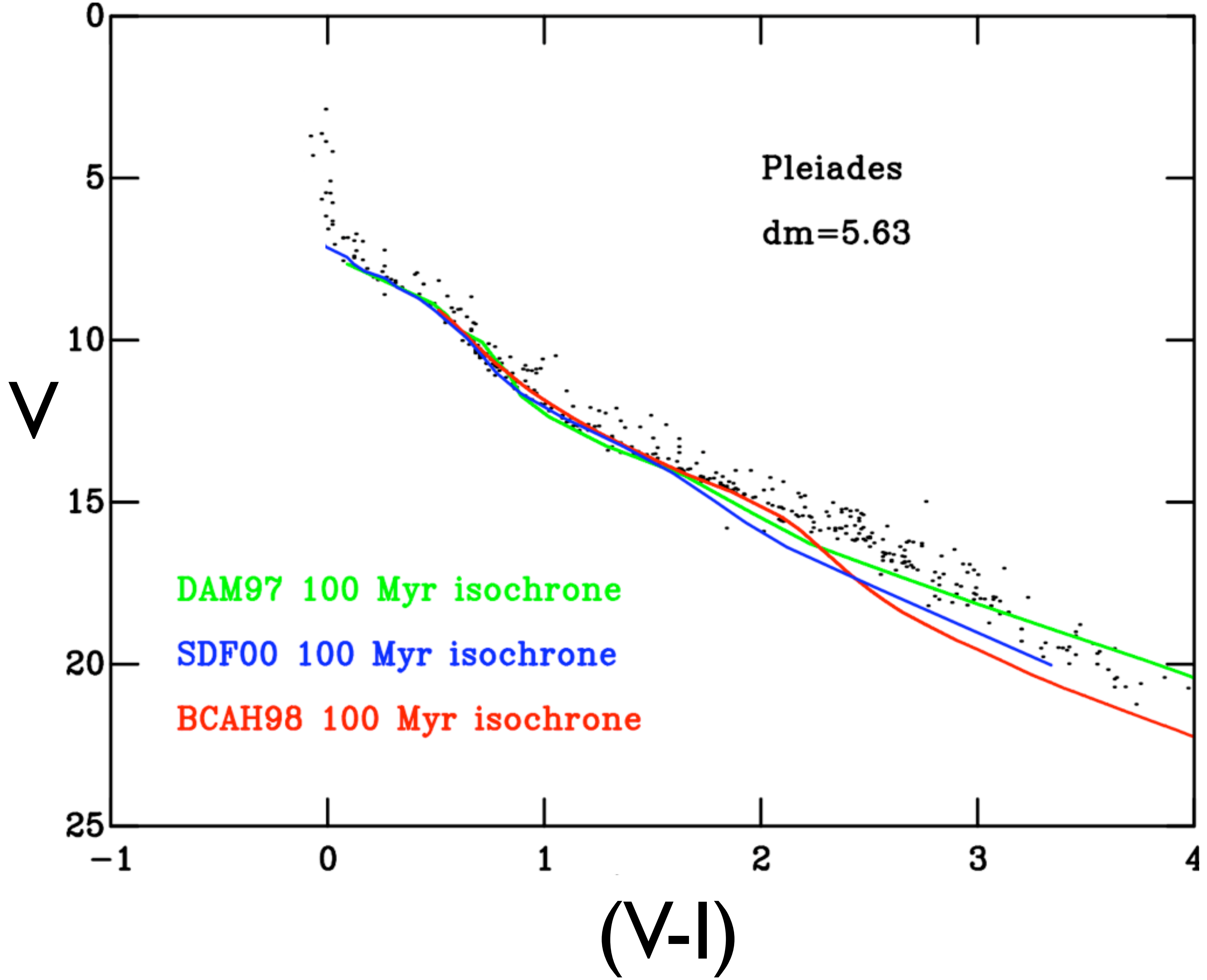
Pleiades ~100 (125) Myrs



MS ✔
pre-MS ✘
$(V\text{-}I)_0 \sim 2$

Opacities?

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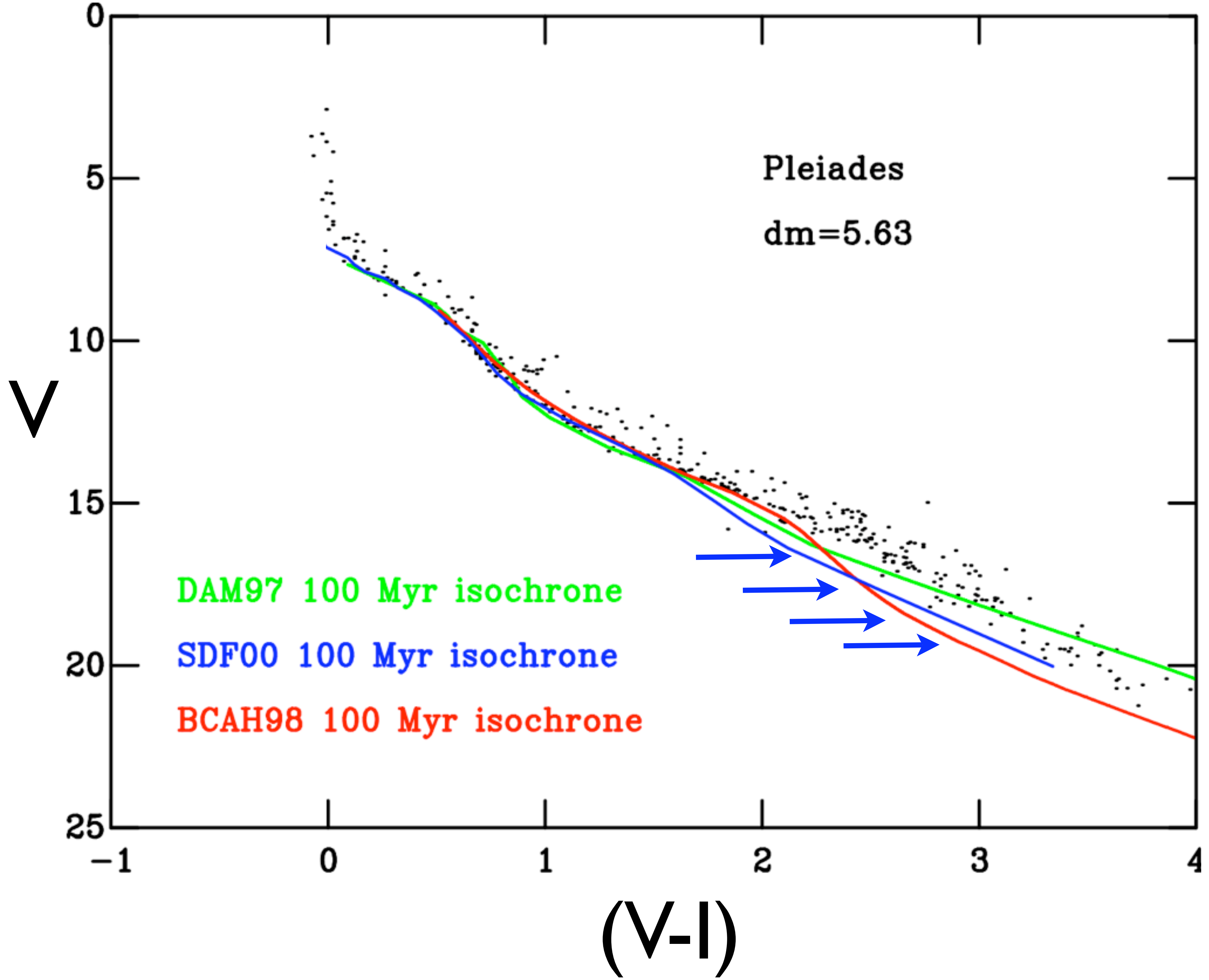
“Pleiades Tuning”-e.g. Jeffries et al (2004)



Semi-empirical:

- Adjust Col-T_{eff}
- Constant M_V

Mass scale?

Log(g)?

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Procedure

- Interior Model: $Age_{i=1}$ & $Mass_j \Rightarrow M_{bol}, T_{eff}$ (R_*), log(g)

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- $M_V = M_{bol} - BC_V(T_{eff})$

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<u>Colour-T_{eff}:</u>

- V = Constant, $\Delta(V\text{-}I)$
- Colour-T_{eff}: $(V\text{-}I)=BC_I-BC_V$

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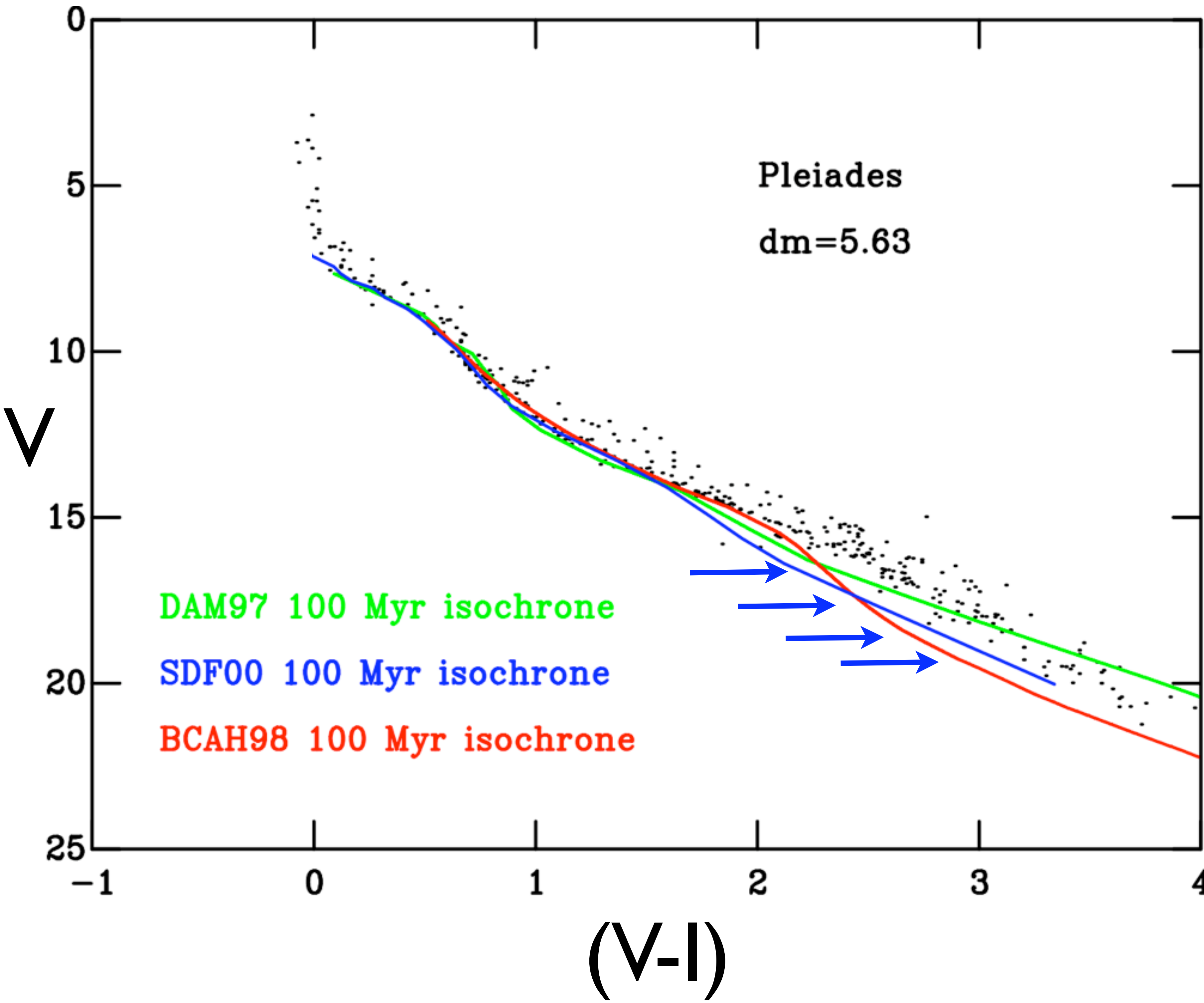
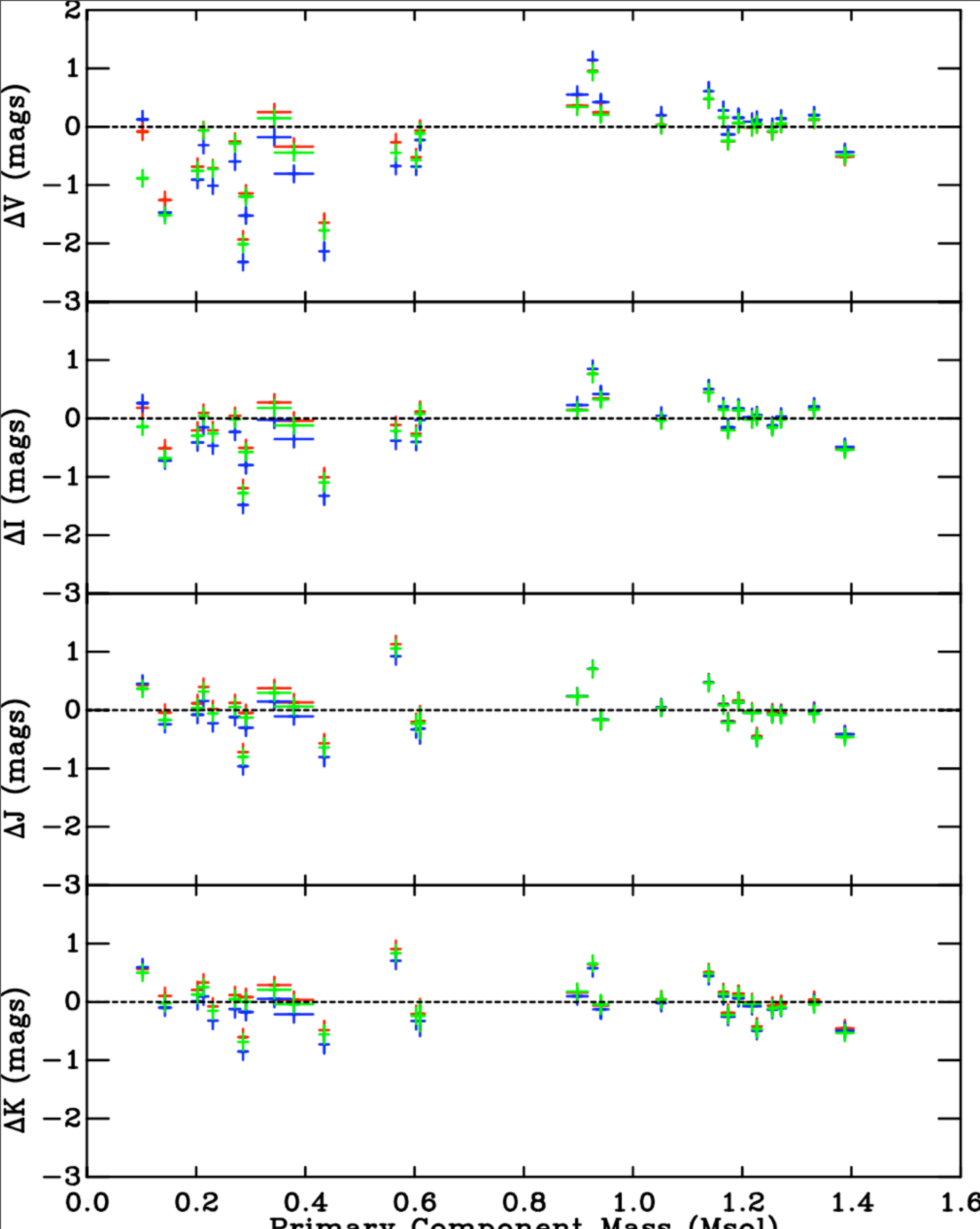


But....

- Δ(V-I),ΔV=0 $\therefore$ ΔI
- Mass?
- log(g) = F(Age)



Version 2.0

Independent Mass ⇒ Binaries

- Eclipsing & Spectroscopic Field Binaries ⇒ Magnitude_{sys}

  ⋆ Mag_P & Mag_s?, separation

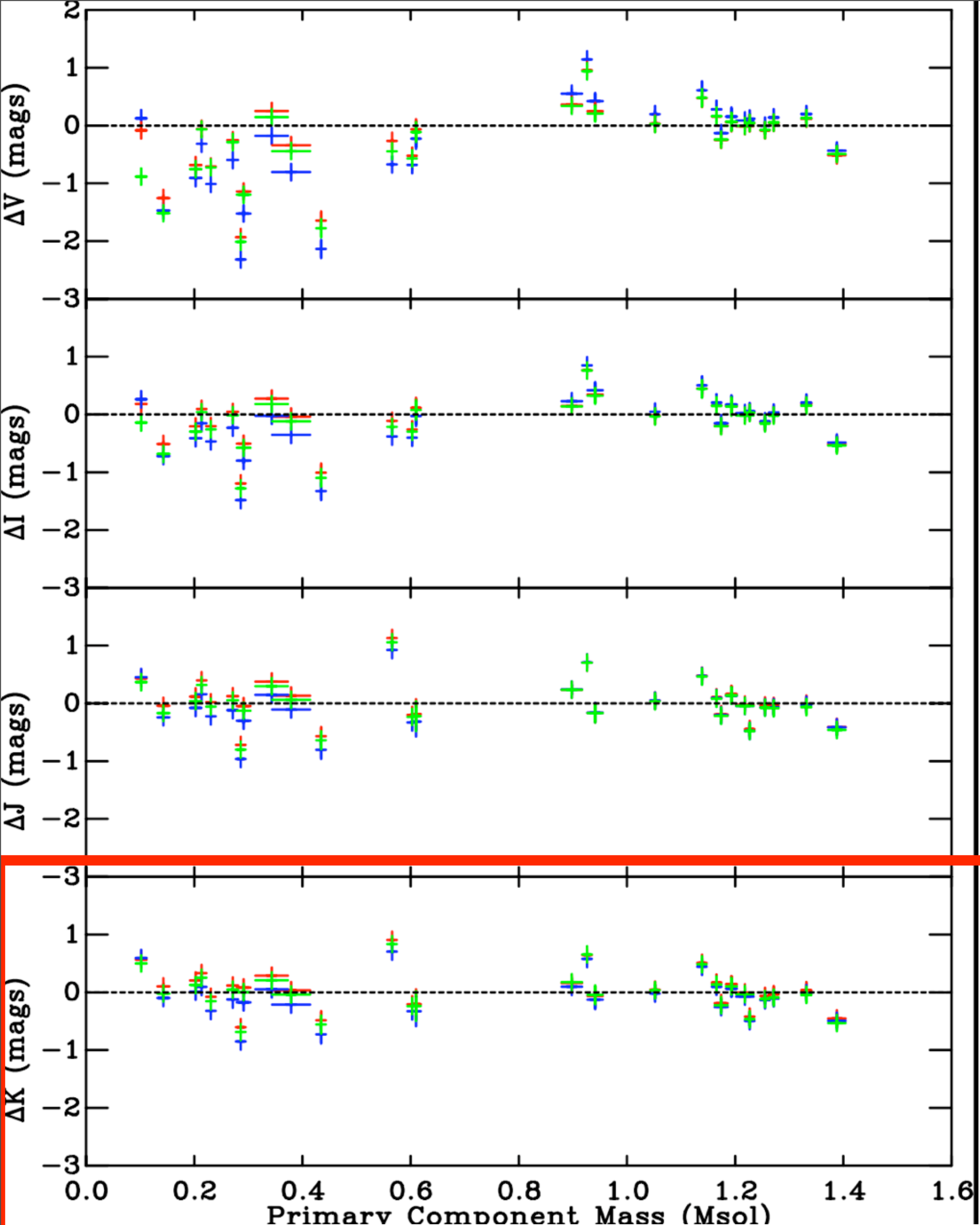
- ΔMagnitude vs M_P (~T_{eff})

  ⋆q→1, same T_{eff}

  ⋆q→0, T_{eff}=Primary

- V ✘, K ✔

Version 2.0



<u>Independent Mass ⇒ Binaries</u>

- Eclipsing & Spectroscopic Binaries ⇒ Magnitude_{sys}

★ Mag_P & Mag_s?, separation

- ΔMagnitude vs M_P ($\sim T_{eff}$)

★q→1, same T_{eff}

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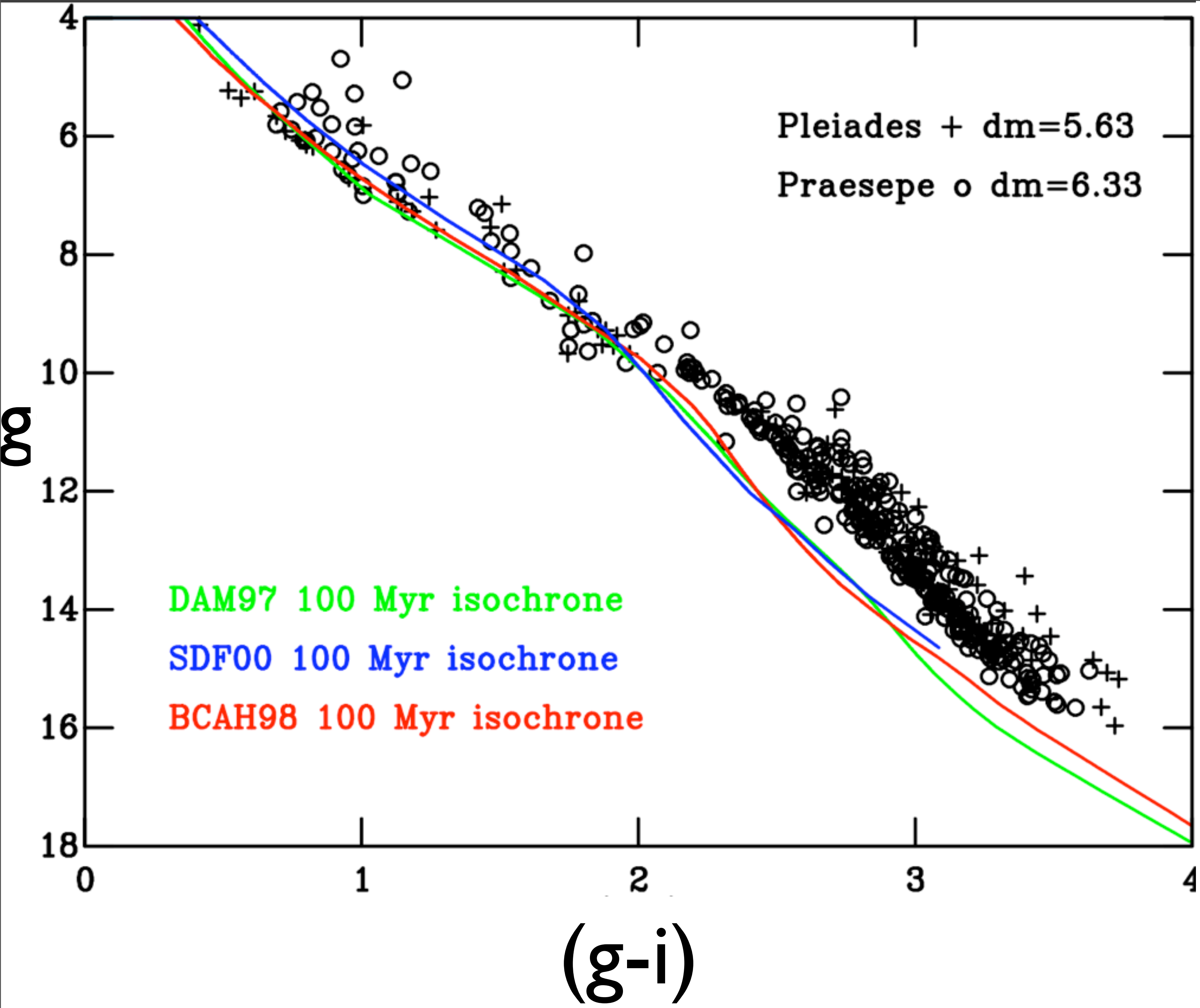


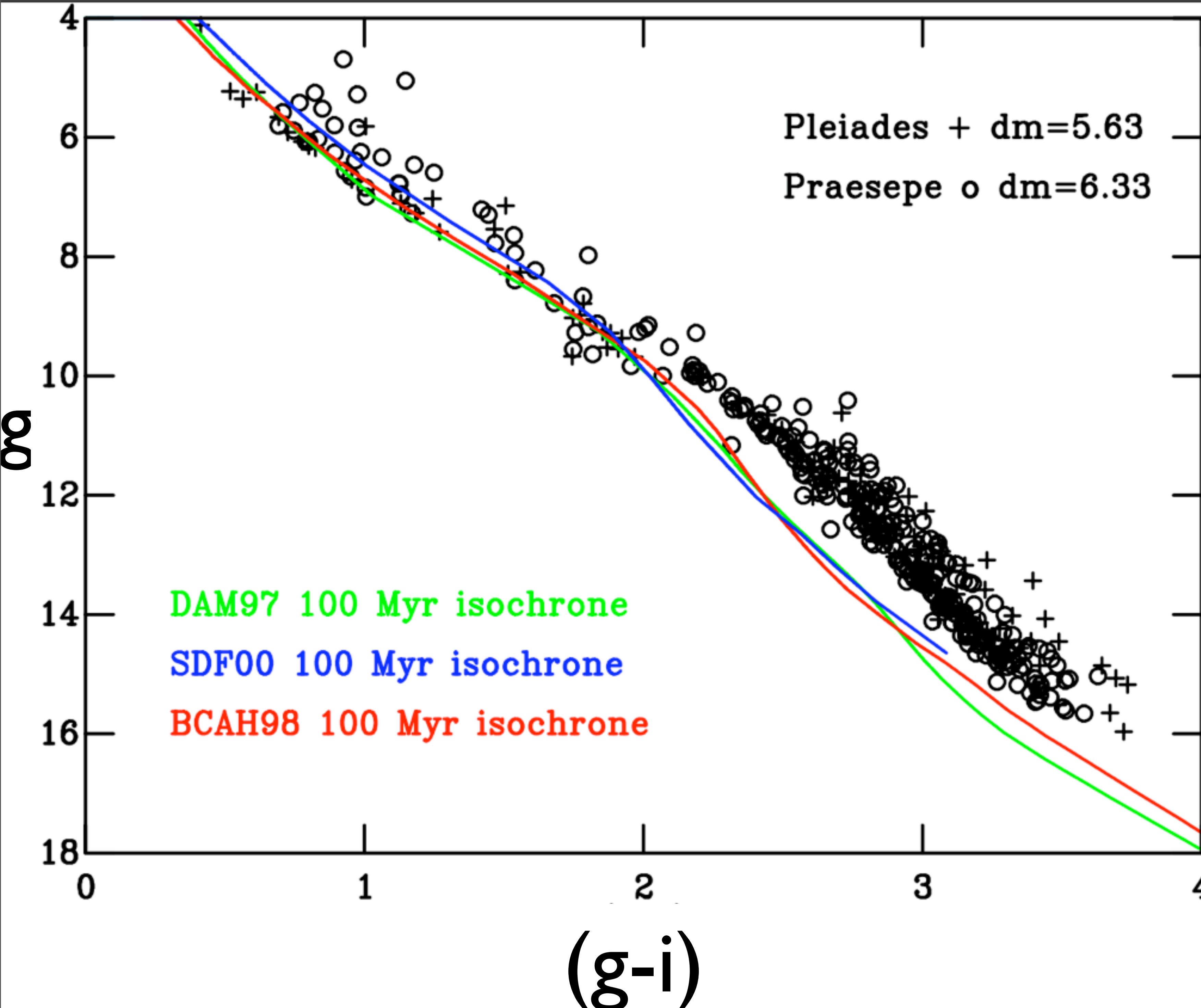
Stellar Parameters:

- Mass
- Age (<20 Myrs)

Pre-MS: Mass

- K band - Disc
- ∴Pleiades, Praesape

Mass scale



Pre-MS: Age

- $BC_\lambda = F(\log(g))$
- Optical (A_V, Δage)

Age Scale

Practicalities:

- Stats: N_{cl} & Area
- Consistent
- Automation

⇒ Sloan, VST

Procedure

- Interior Model: $Age_{i=1}$ & $Mass_j \Rightarrow M_{bol}, T_{eff}$ (R_*), log(g)
- Atmosphere Model: $Log(g)_{i=1}, T_{eff,j} \Rightarrow Spectra_i$
- Filter response (+ZP): $Spectra_i \Rightarrow M_V, (V\text{-}I)_0$
- $M_V = M_{bol} - BC_V(T_{eff})$

New Colour-T_{eff} (K,V-K⇒V,V-I):

- Pleiades: K = Constant, Δ(V-K)
- Colour-T_{eff}: $V = BC_V(\log(g), T_{eff})$
- K = Constant, Δ(V-I)
- Colour-T_{eff}: $(V\text{-}I) = BC_I(\log(g), T_{eff}) - BC_V(\log(g), T_{eff})$

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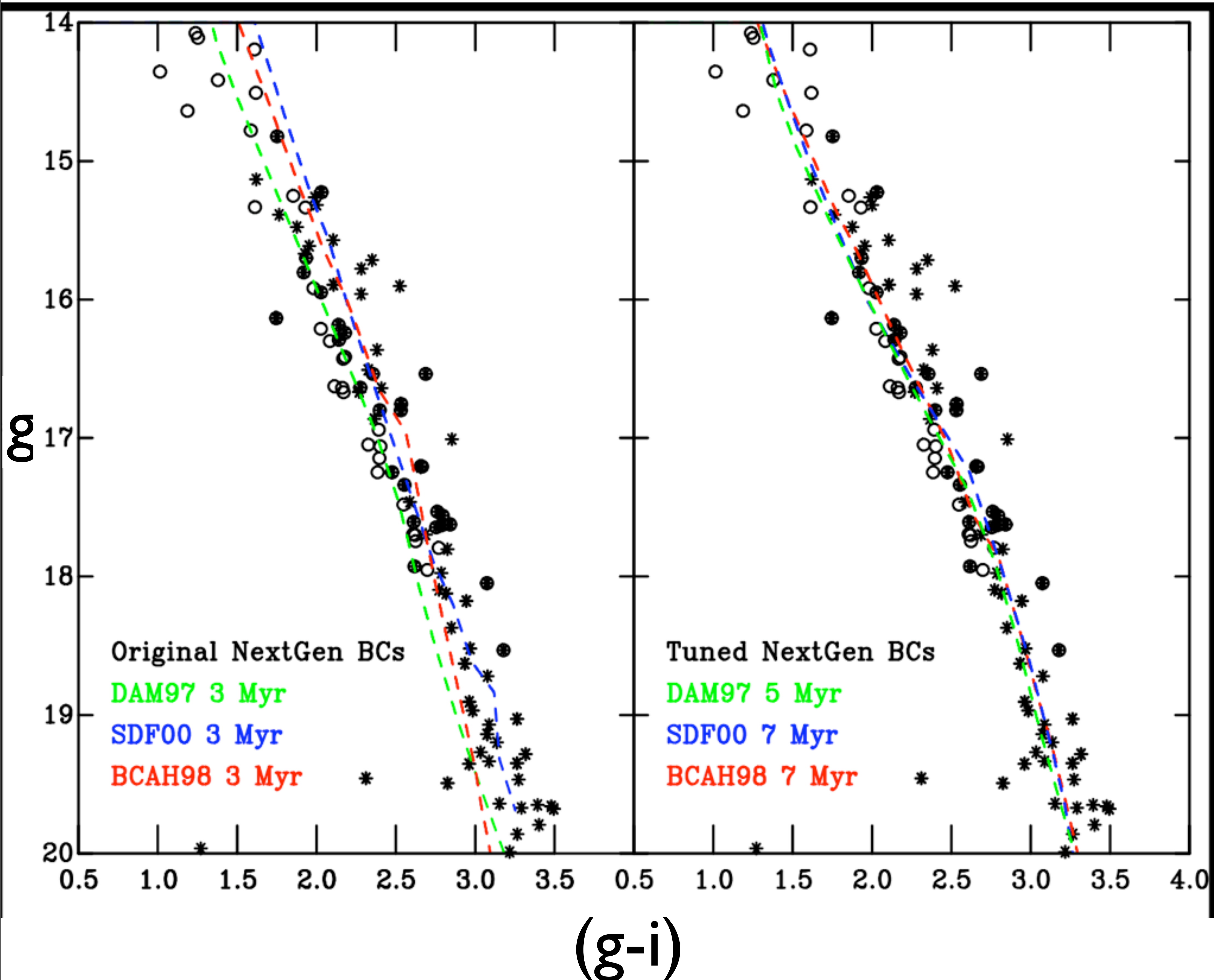
The Test

- λ Ori, 7 Myrs (distance & Av, Mayne & Naylor, 2008)



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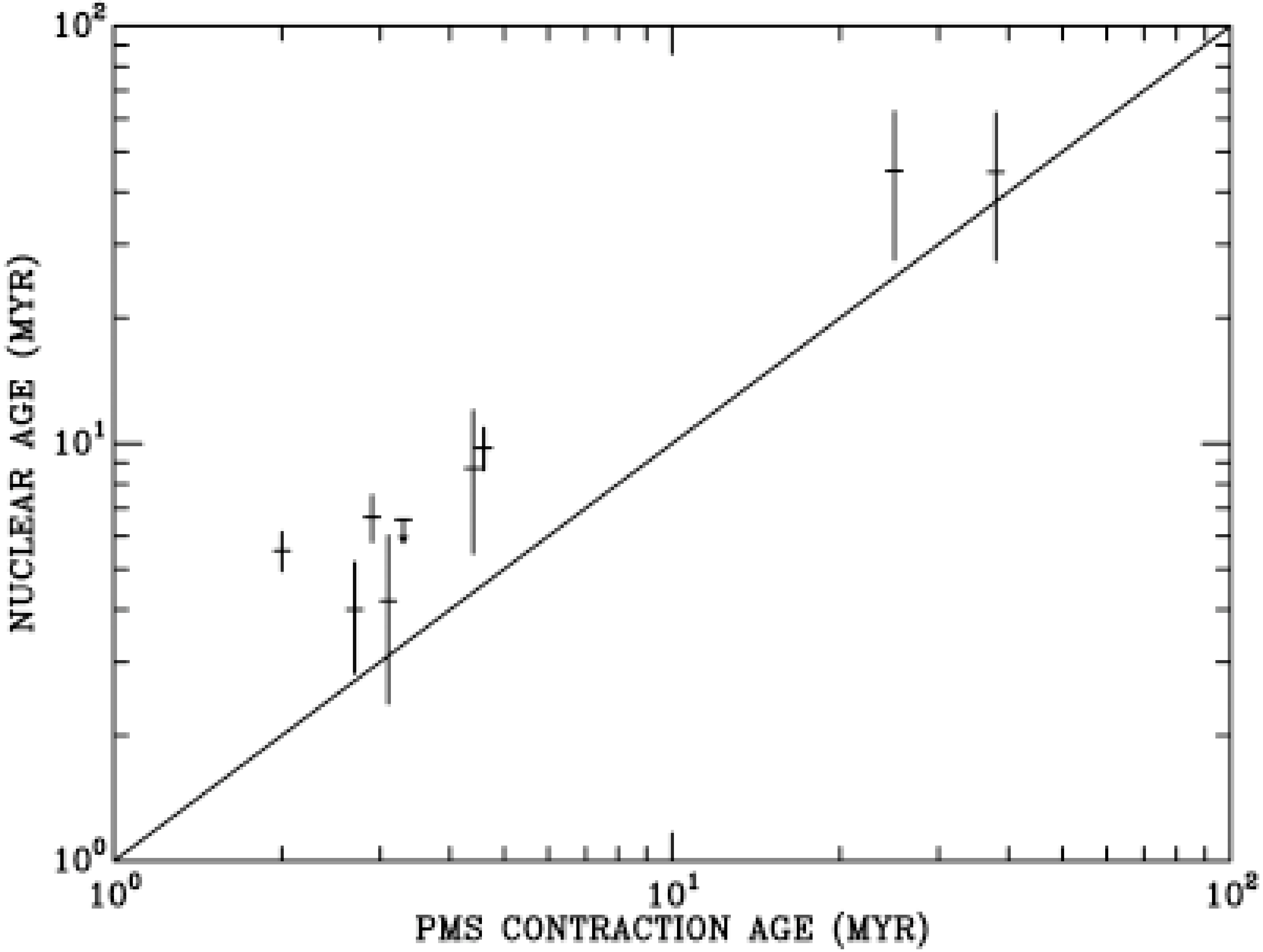
New age consistent with post-MS (Naylor, 2009)



Conclusions.

- Improved set of semi-empirical isochrones (any magnitude, colour and age).
- Fit throughout observed sequence.
- New models? ⇒ Automated.
- Mass scale consistent with age scale
- Age(pre-MS) ~ Age(nuclear).
    - ★ Current ages factor 1.5-2 too young!

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Accreting Brown Dwarfs with Discs: http://bd-server.ex.ac.uk/

Nathan Mayne & Tim Harries.
(nathan@astro.ex.ac.uk)

Abstract: We present analysis from Mayne & Harries (2010) of a grid of ~10^6 accreting brown dwarf and disc (BDD) systems modeled using the TORUS radiative transfer code. Including dust sublimation, vertical hydrostatic equilibrium (or analytical vertical structure), realistic input stellar spectra and accretion from the co-rotation radius onto a surface hot spot. SEDs and photometry (magnitudes and monochromatic fluxes) have been derived for several inclinations and filters.
For accretion rates above $M_{acc}=10^{-9}(M_{sol}\ yr^{-1})$, flaring, photospheric veiling and dust sublimation become significant. Additionally, the accuracy of photometric age and mass, derivation decreases with accretion rate, suggesting any $M_{acc} \propto M_*^2$ relationship contains selection biases. For our model grid current disc fraction cuts perform reasonably, however, we present improved selections.
Finally, SEDs and photometry for all models are available online alongside a fitting tool (beta) including χ^2 fitting and degeneracy analysis:
http://bd-server.ex.ac.uk/.

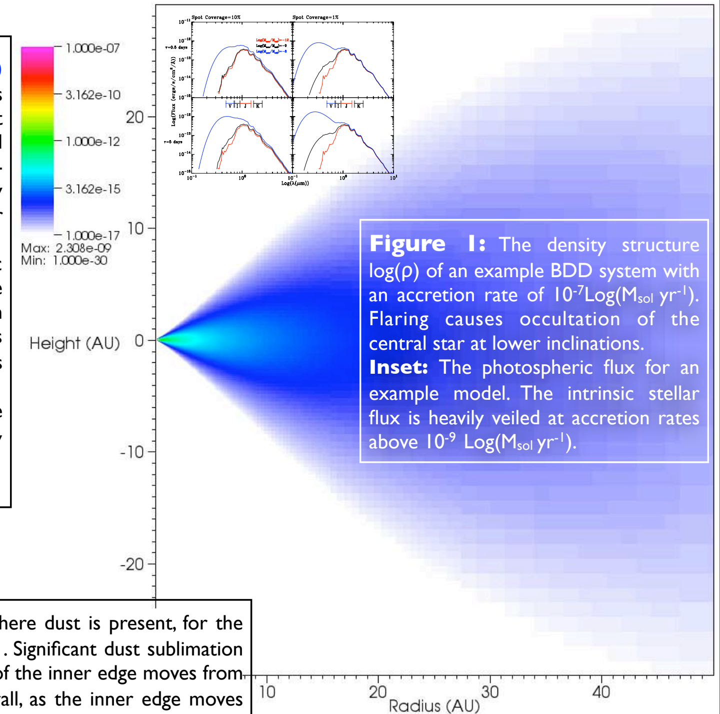


Figure 1: The density structure log(ρ) of an example BDD system with an accretion rate of 10^{-7}Log($M_{sol}\ yr^{-1}$). Flaring causes occultation of the central star at lower inclinations.
Inset: The photospheric flux for an example model. The intrinsic stellar flux is heavily veiled at accretion rates above 10^{-9} Log($M_{sol}\ yr^{-1}$).

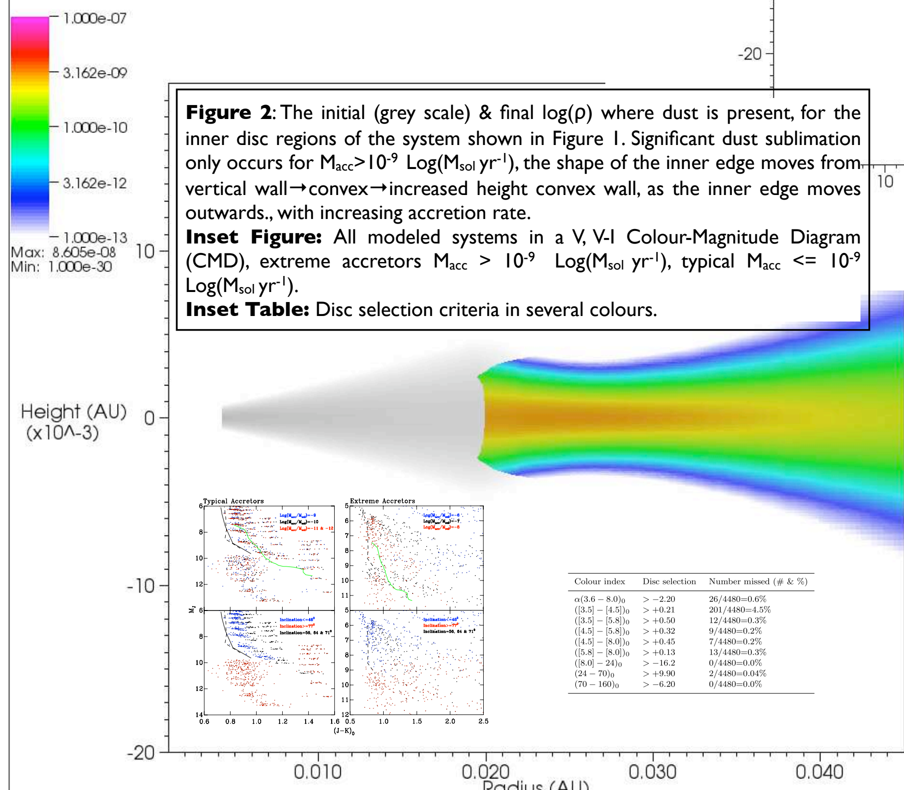
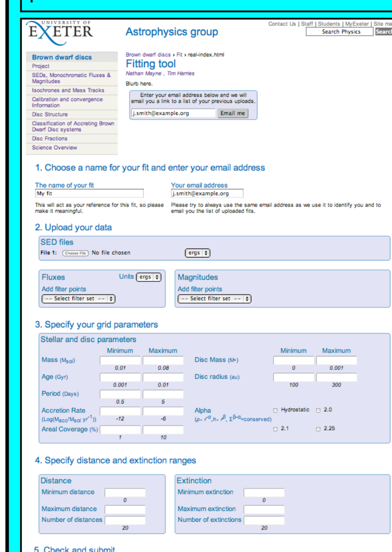


Figure 2: The initial (grey scale) & final log(ρ) where dust is present, for the inner disc regions of the system shown in Figure 1. Significant dust sublimation only occurs for $M_{acc}>10^{-9}$ Log($M_{sol}\ yr^{-1}$), the shape of the inner edge moves from vertical wall→convex→increased height convex wall, as the inner edge moves outwards., with increasing accretion rate.
Inset Figure: All modeled systems in a V, V-I Colour-Magnitude Diagram (CMD), extreme accretors $M_{acc} > 10^{-9}$ Log($M_{sol}\ yr^{-1}$), typical $M_{acc} <= 10^{-9}$ Log($M_{sol}\ yr^{-1}$).
Inset Table: Disc selection criteria in several colours.

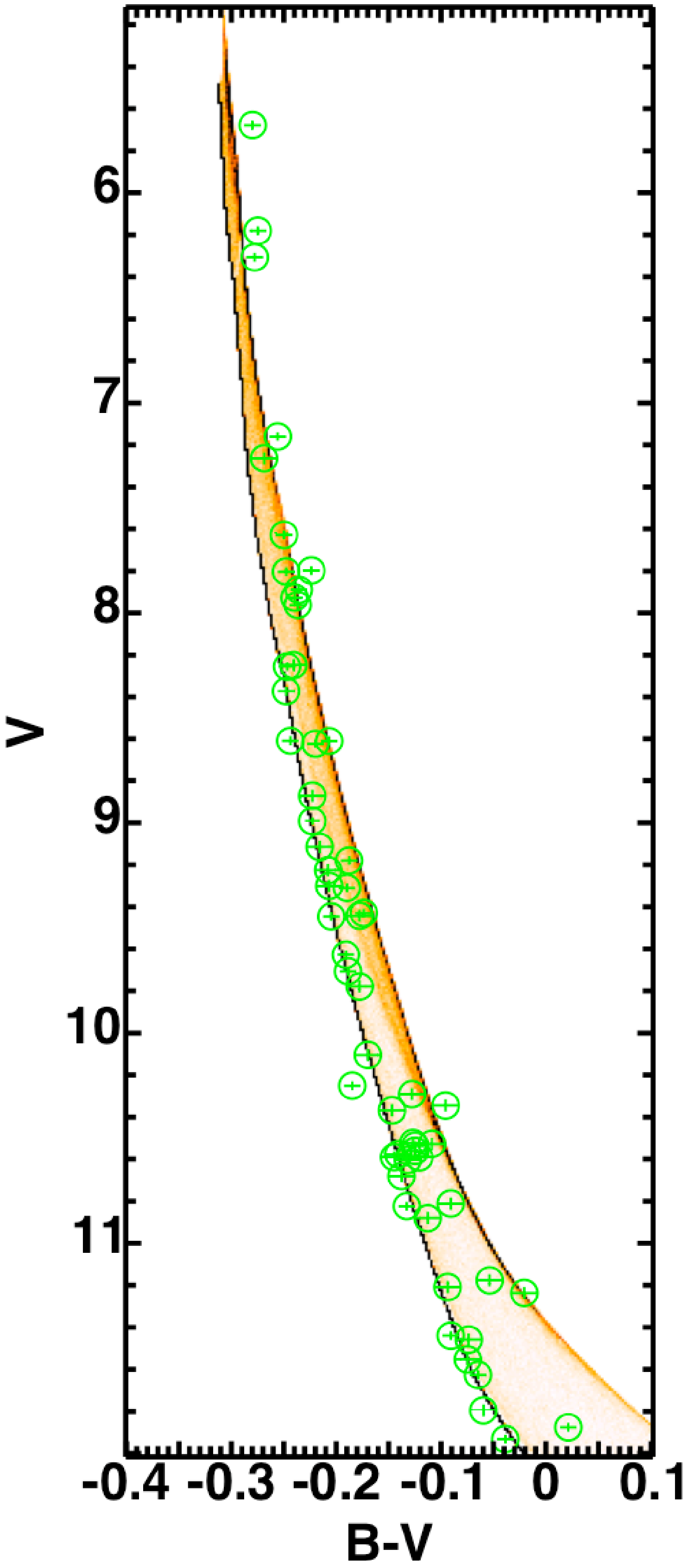
Colour index	Disc selection	Number missed (# & %)
$\alpha(3.6-8.0)_0$	> -2.20	26/4480=0.6%
$([3.5]-[4.5])_0$	$> +0.21$	201/4480=4.5%
$([3.5]-[5.8])_0$	$> +0.50$	12/4480=0.3%
$([4.5]-[5.8])_0$	$> +0.32$	9/4480=0.2%
$([4.5]-[8.0])_0$	$> +0.45$	7/4480=0.2%
$([5.8]-[8.0])_0$	$> +0.13$	13/4480=0.3%
$([8.0]-24)_0$	> -16.2	0/4480=0.0%
$(24-70)_0$	$> +9.90$	2/4480=0.04%
$(70-160)_0$	> -6.20	0/4480=0.0%

Access & Fitting: All models from Mayne & Harries (2010) are available to browse and download at: http://bd-server.ex.ac.uk/. There is also a fitting tool allowing users to upload multiple SEDs, magnitudes and monochromatic fluxes, and fit these to the whole, or a subset of the grid. The best fitting models along with uncertainties and degeneracy analysis are presented to the user.



Conclusions: For accreting BDD systems increased occultation and cooler photospheres compared to CTTS, leads to increased difficulty in spectroscopic or photometric derivation of the correct stellar properties. In fact, as the accretion rate increases the BDD systems move farther from their expected photometric locus and the underlying SEDs become more heavily veiled. This suggests that objects with higher accretion rates will not be included in samples of brown dwarfs, suggesting an implicit bias in the suggested $M_{acc} \propto M_*^2$ relationship. Improved disc fraction selection criteria are presented (inset table Fig 2).

Paper: Mayne & Harries (2010). URL: http://bd-server.ex.ac.uk/



Nuclear Ages

NGC 6530
0.25 Myr (Geneva-Bessell)
$Pr(\tau^2)=0.03$

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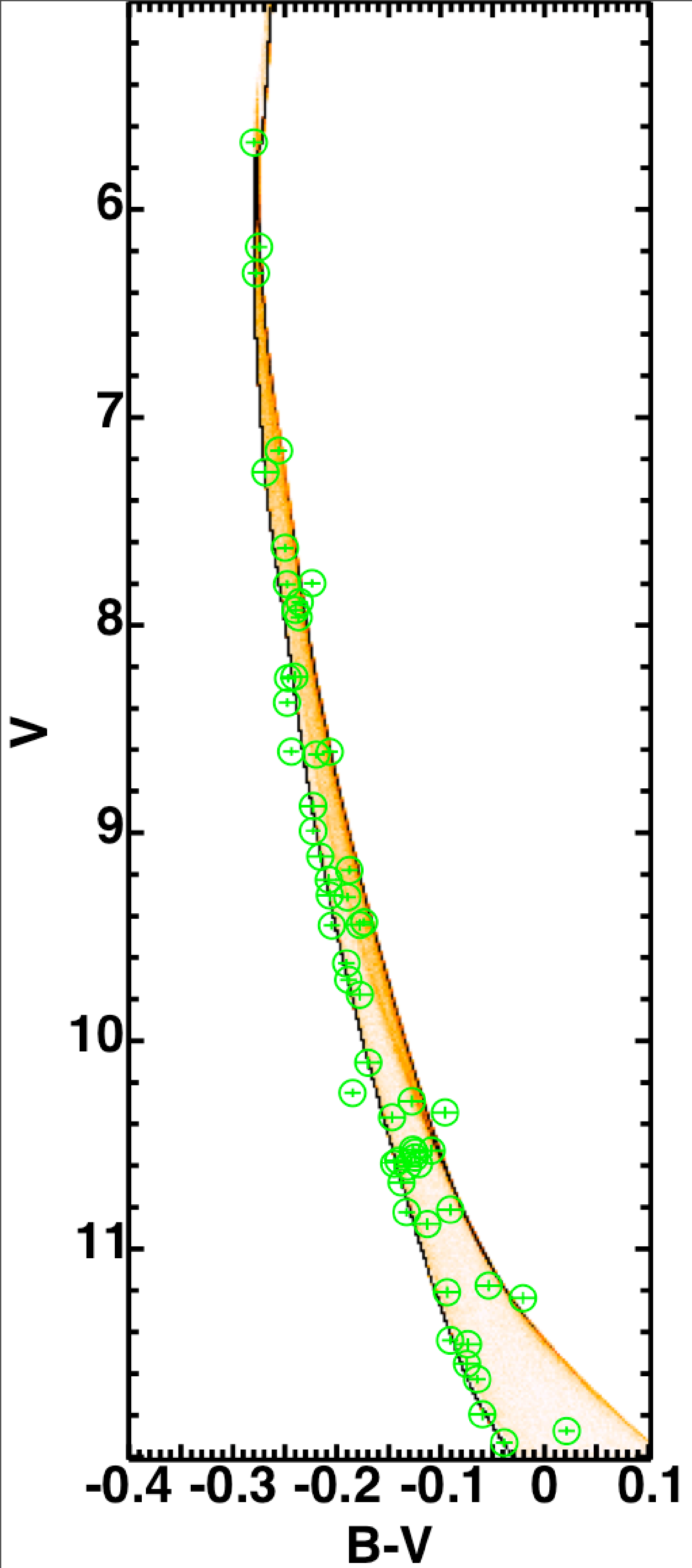
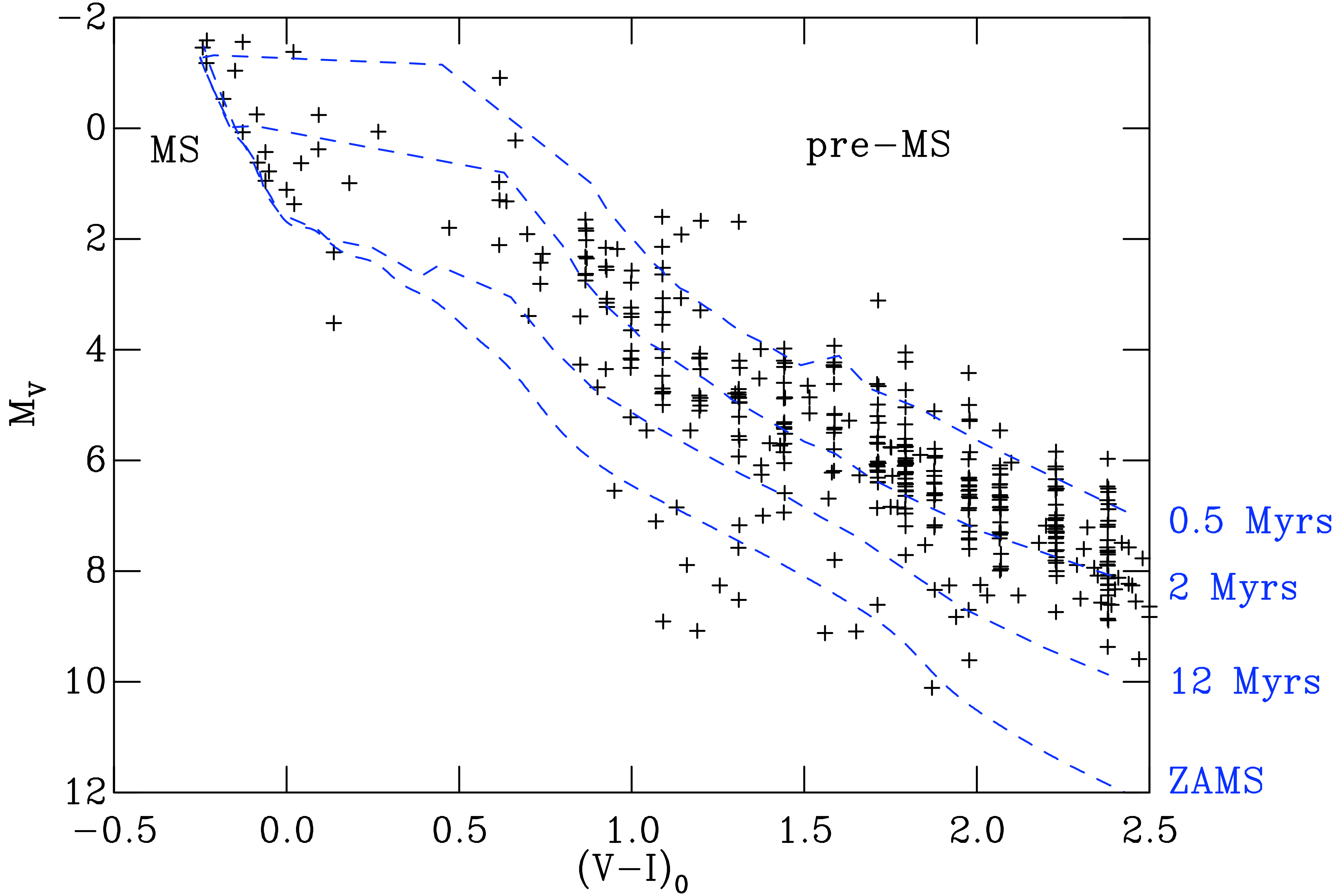


Nuclear Ages

NGC 6530
5.50 Myr (Geneva-Bessell)
$Pr(\tau^2)=0.67$

c.f. 2 Myr PMS isochronal
(contraction) age



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