How old is Beta Pic?

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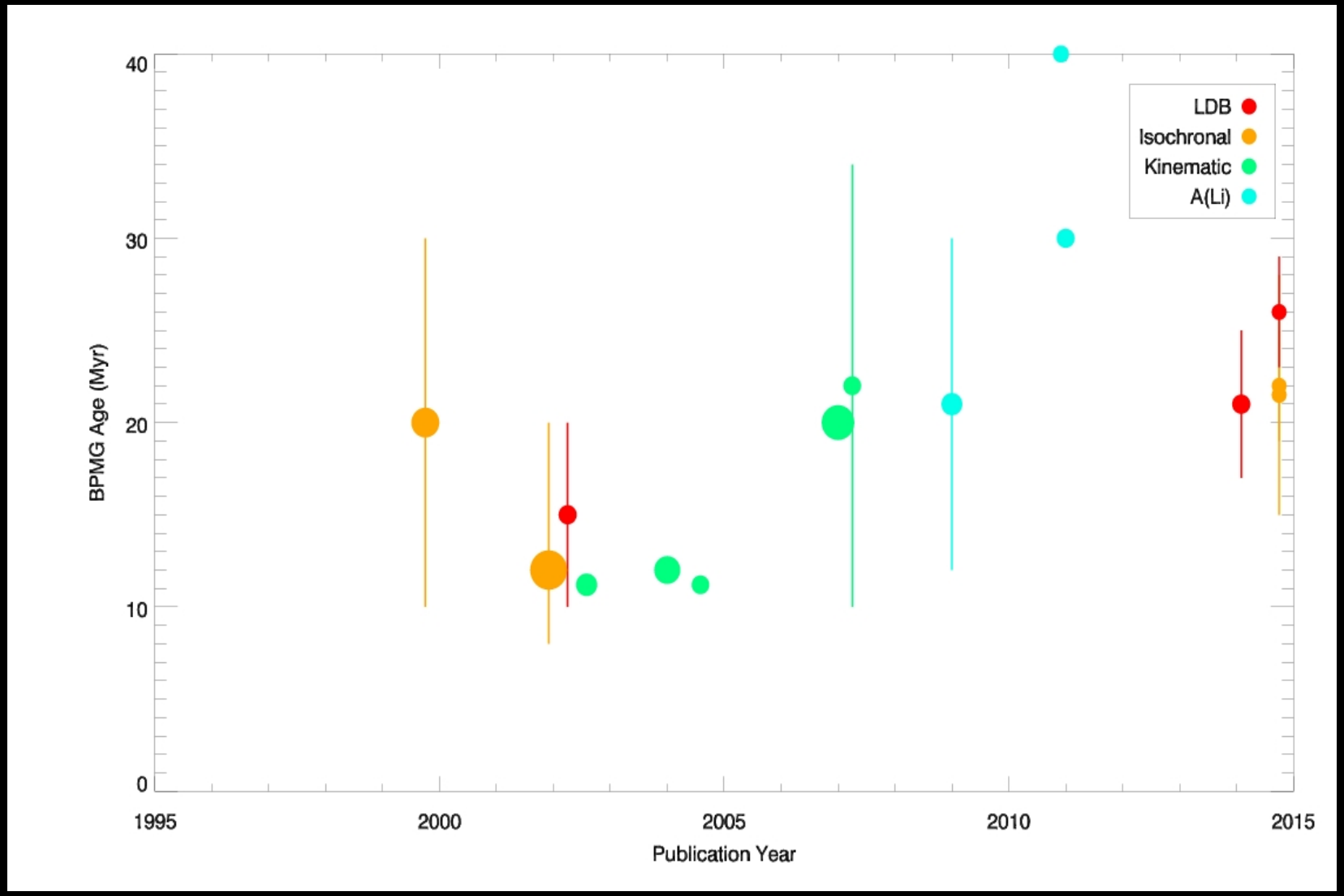
The age of BPMG over time



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Early age estimates

AGE (Myr)	REASON	REFERENCE
≤ 200	Under-luminous compared to MS.	Paresce 1991
As young as 10	Debris disk compared to young analog HR4796.	Jura et al. 1993
Double valued, 12 or 3000	HR diagram, debris disk.	Lanz et al. 1995
≥ 100	Sublimating comets can replenish disk material.	Brunini et al. 1996
8 – 100	Near to, or just on the ZAMS.	Crifo et al. 1997
200 ± 100	POTENTIALLY PART OF A MOVING GROUP.	Barrado 1998

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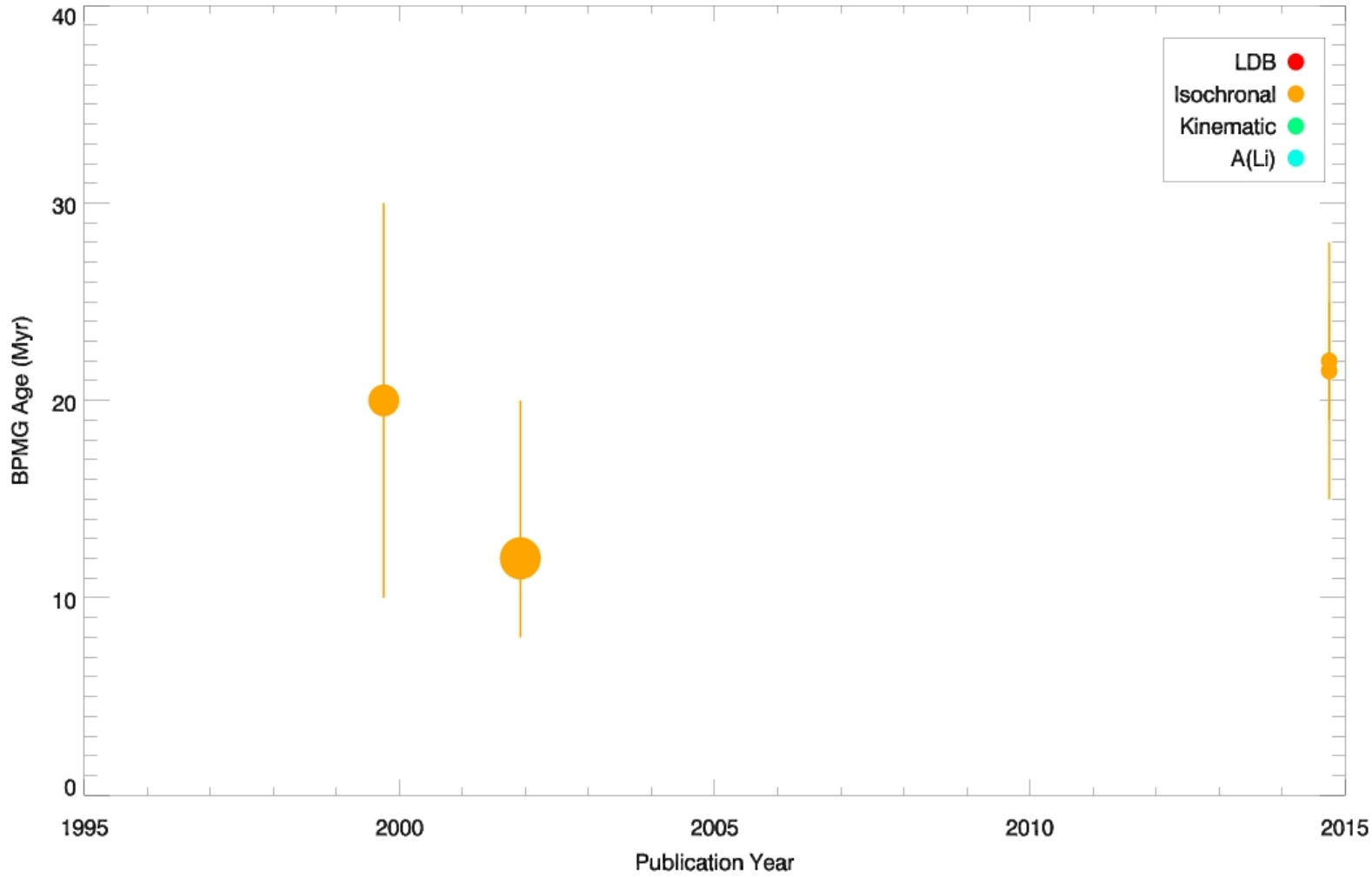
Isochronal ages



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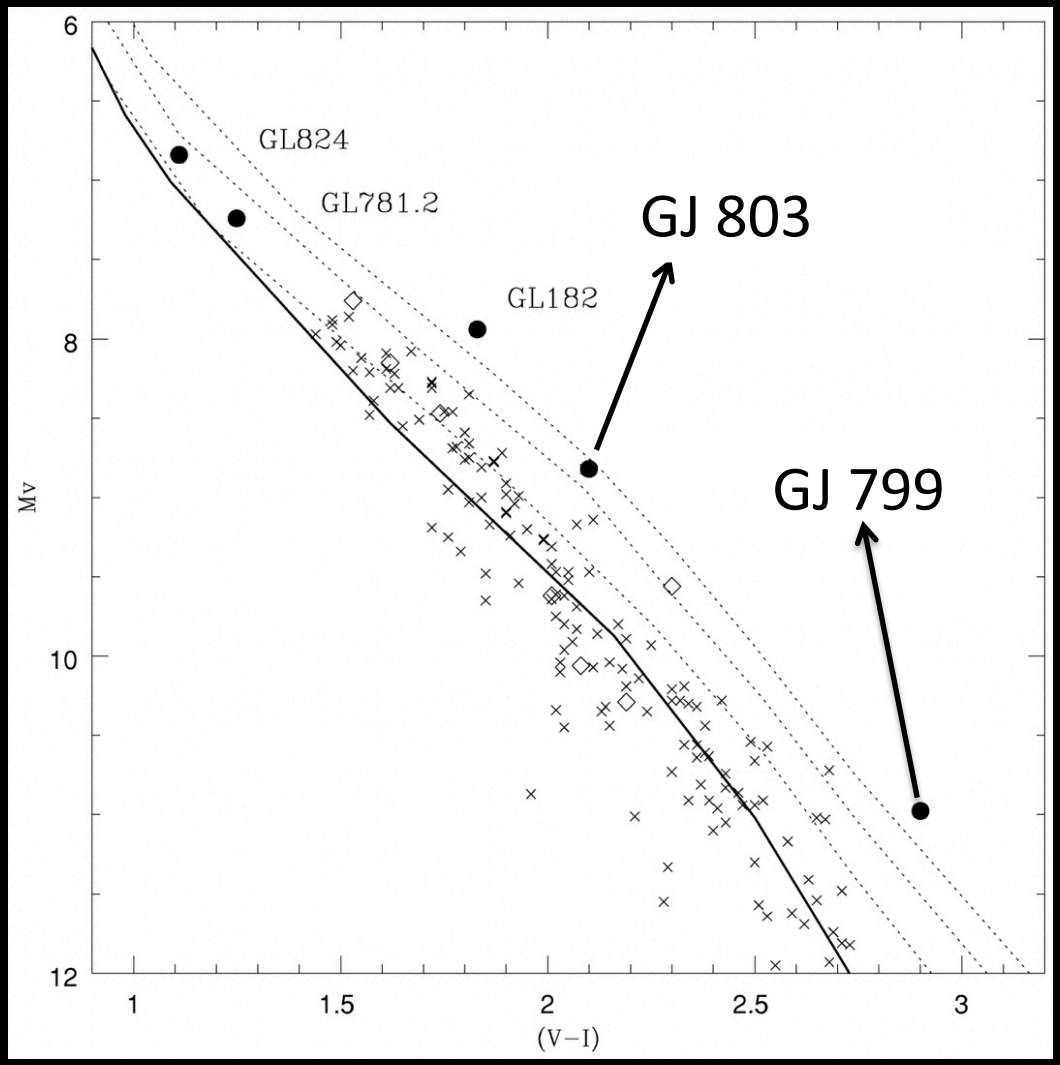
Barrado y Navascues et al. 1999



- CMD (KM stars, M_V vs V-I)
- 2 objects: GJ799, GJ803 The BPMG!
- UVW and age
- Age: 20 ± 10 Myr

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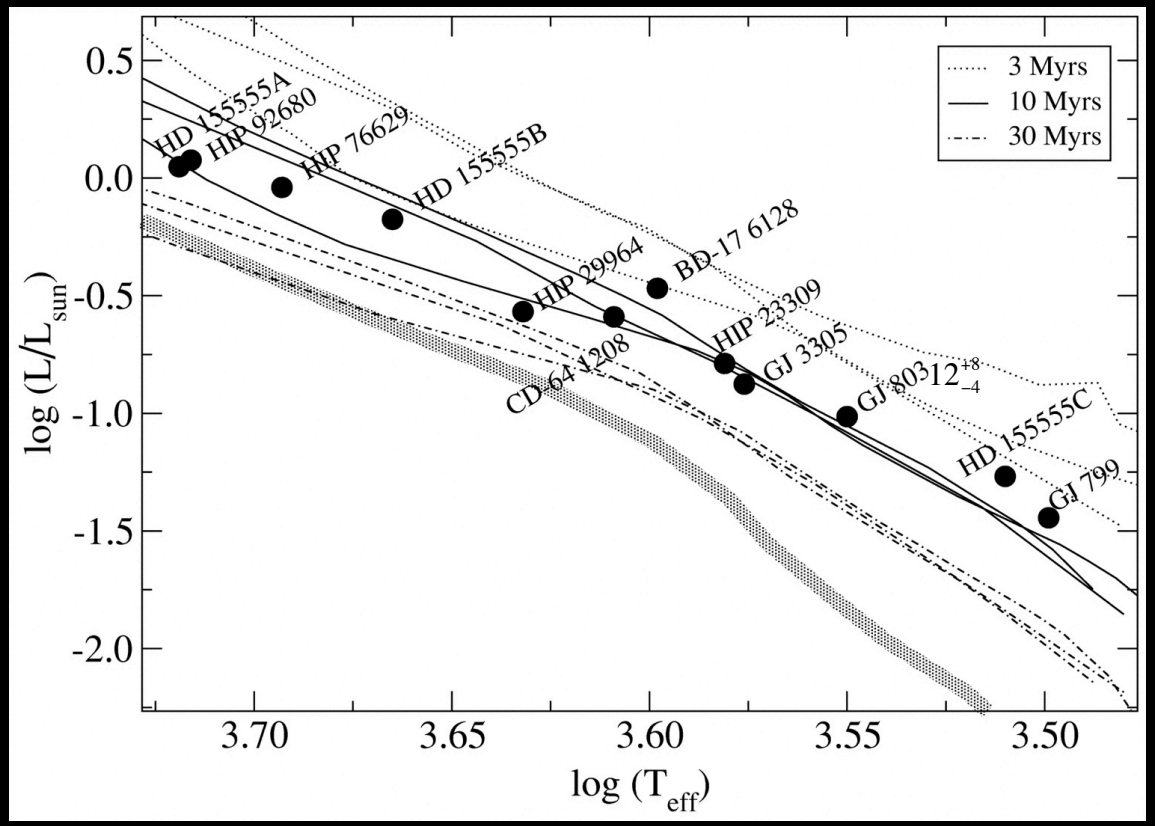
Zuckerman et al. 2001



- HR diagram (GKM)
- 18 new star systems
- Convert M_V vs V-I to theoretical plane
- Age: 12^{+8}_{-4} Myr

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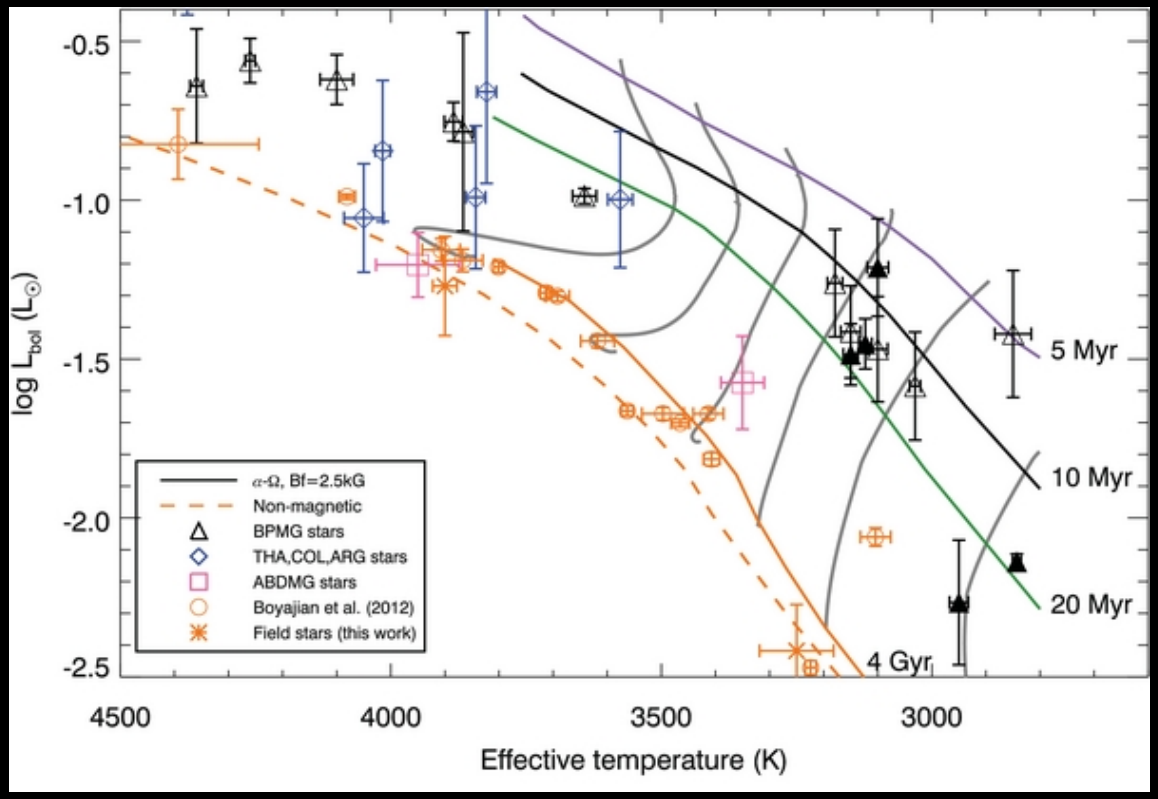
Malo et al. 2014



- HR diagram (KM)
- Sample of 'bonafide' stars from Malo et al. 2013
- Dartmouth models, <B>=2.5kG
- Age: 21 ± 6.5 Myr

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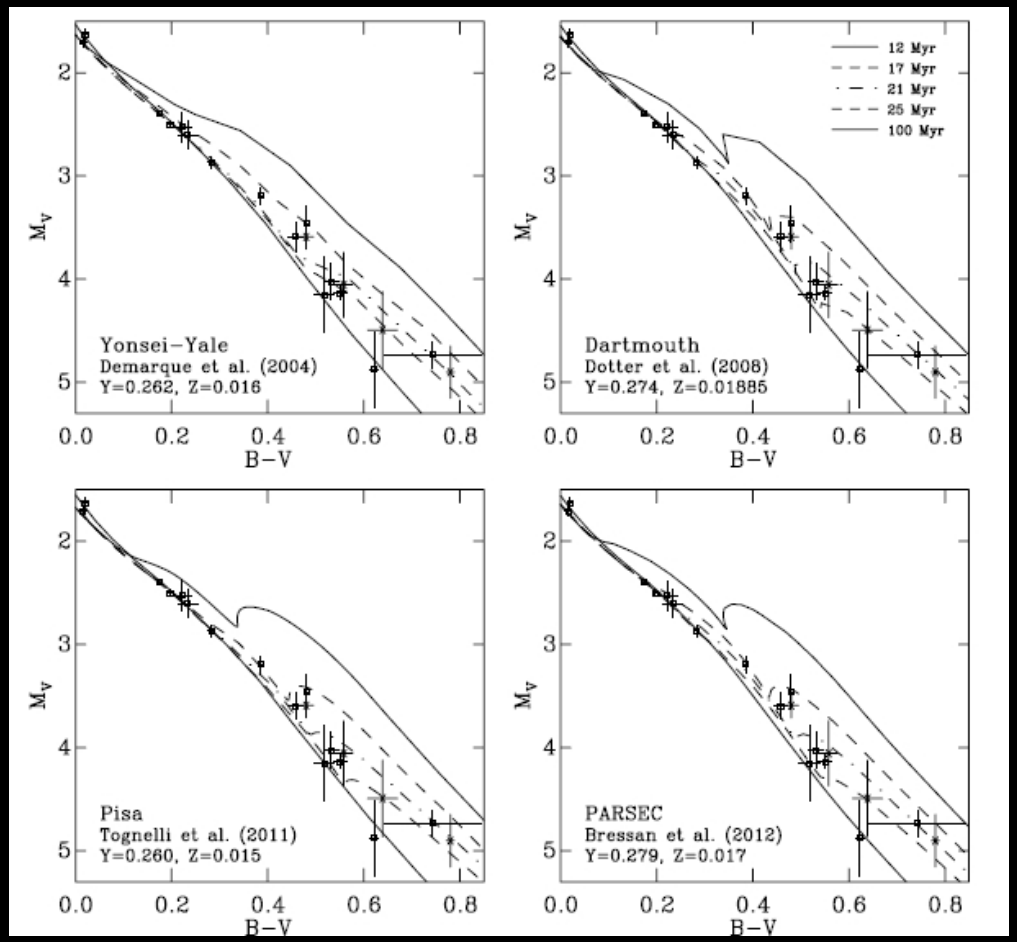
Mamajek & Bell 2014 (in prep)



- CMD (AFG stars, M_V vs V-I)
- Revised astrometry
- 4 separate evolutionary models
- Age: 22 ± 3 Myr

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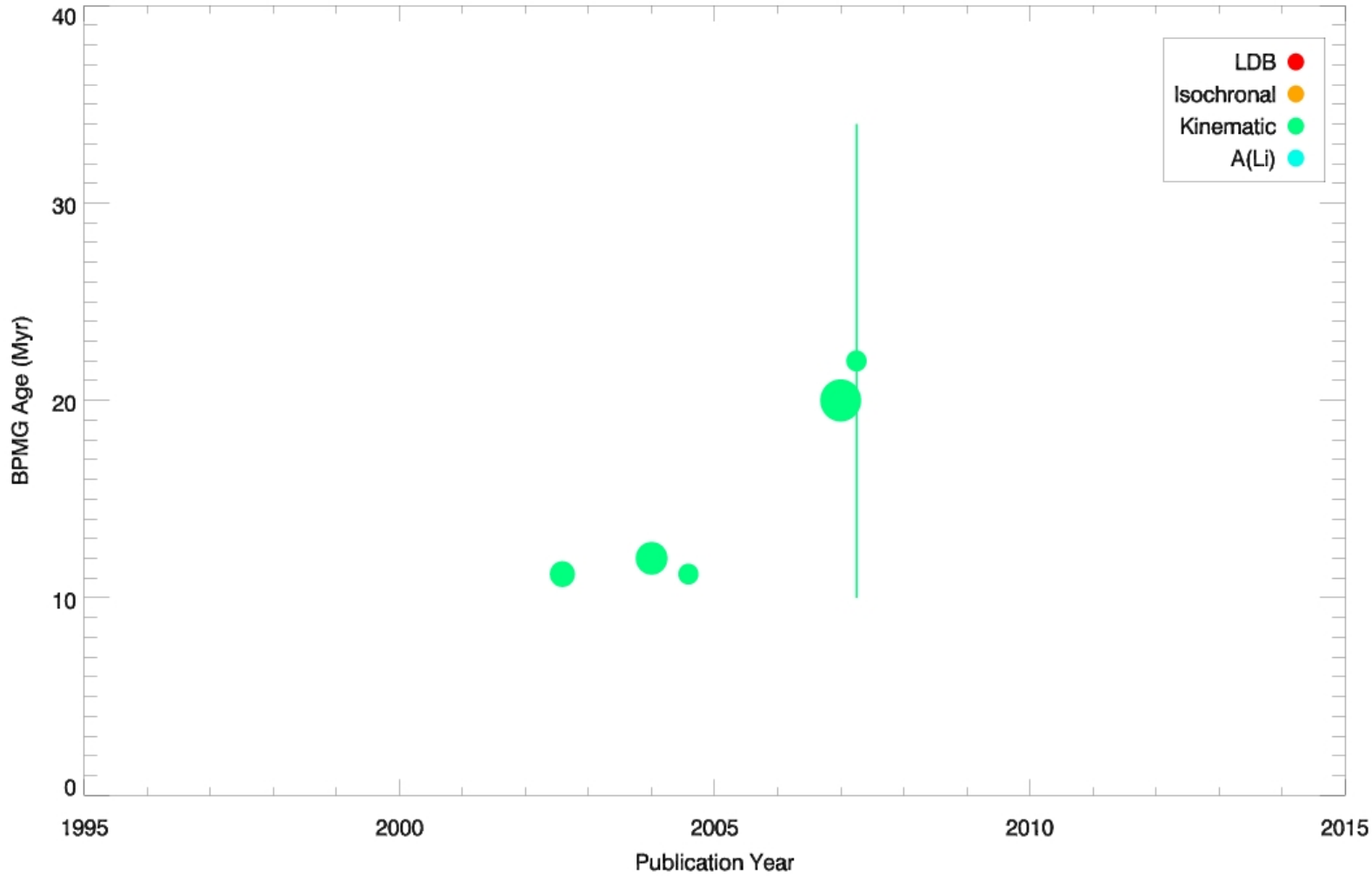
Kinematic ages



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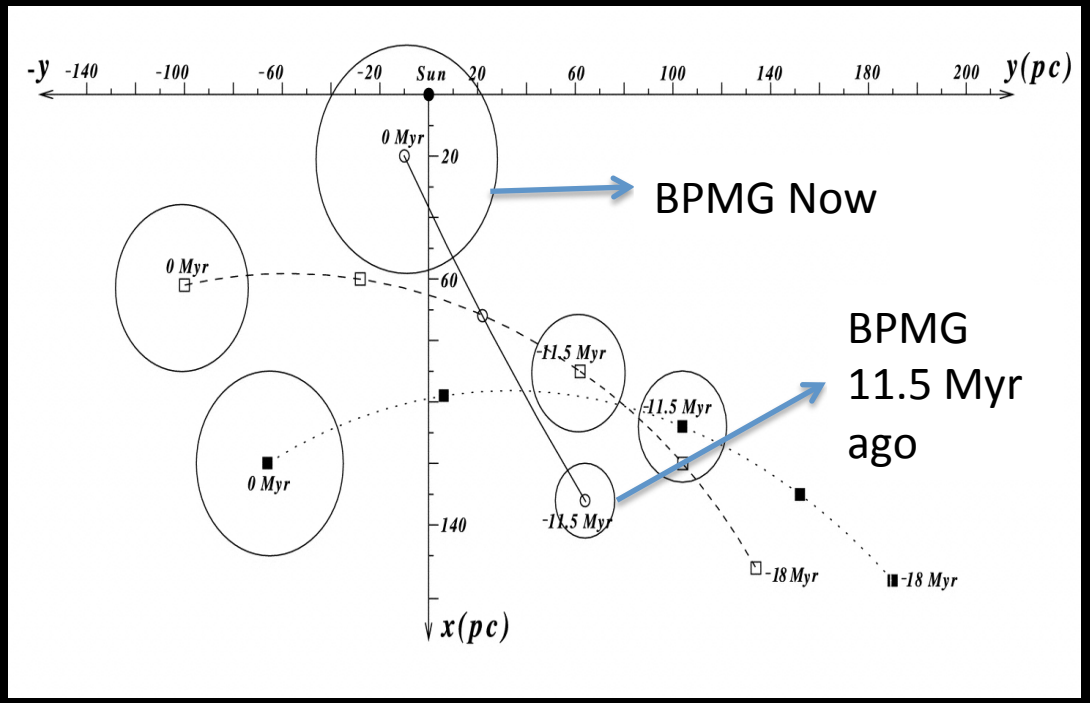
Ortega et al. 2002, 2004



- Traceback orbits of all BPMG members
- First min at -11.5 Myr (1/3 of today's size)
- Birthsite near UCL, LCC?
- Error bars?

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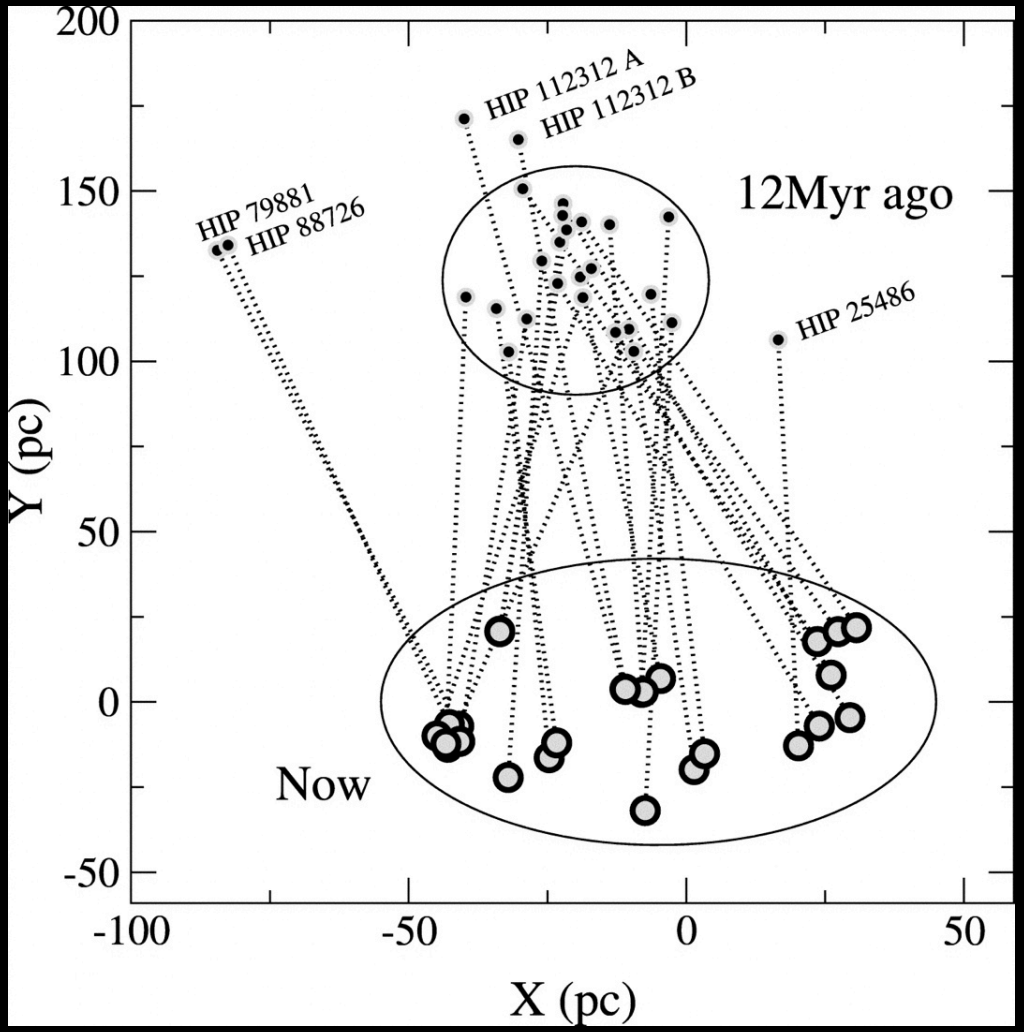
Song et al. 2003



- ‘Only works < 15 Myr’
- Observe a min at 12 Myr
- Positional error of 12 pc based on HIP112312AB
- Outliers?

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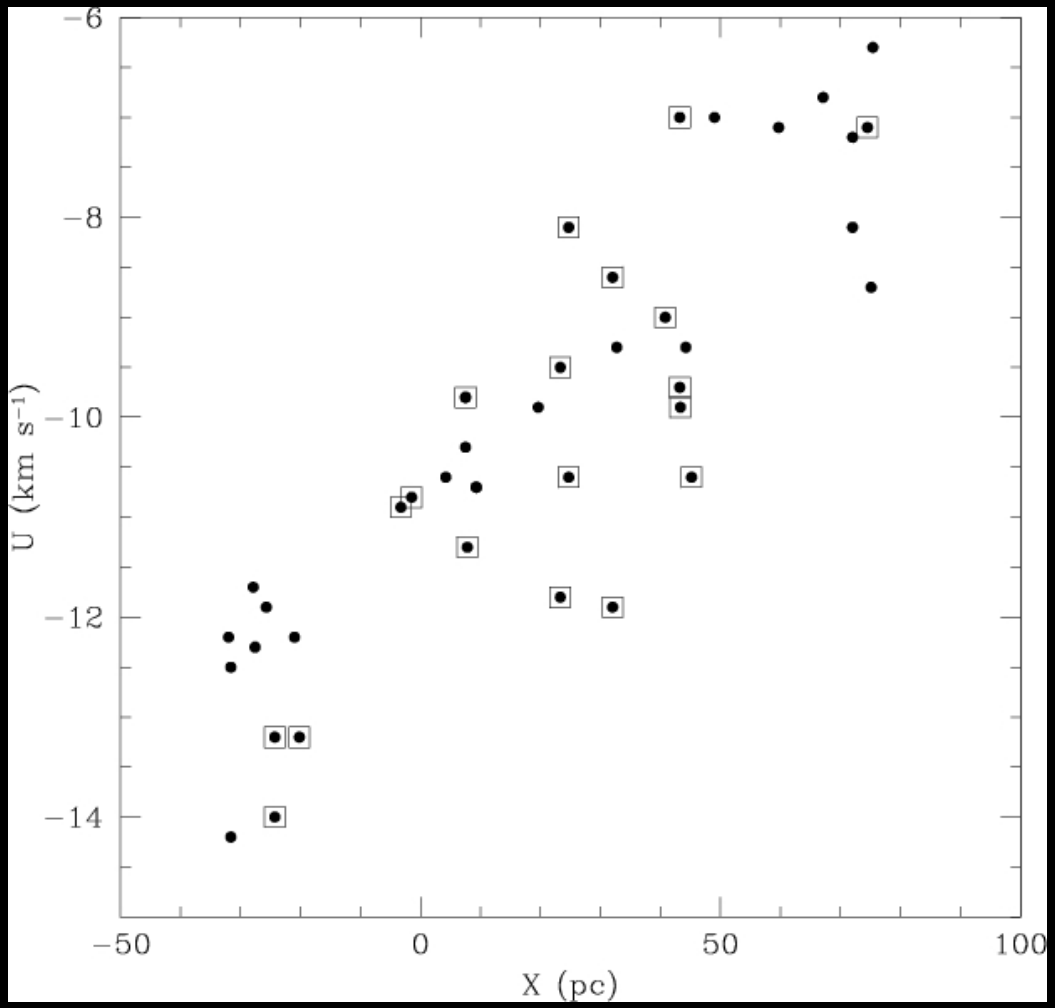
Torres et al. 2006



- Observe how the group has expanded
- $dU/dX = 0.053$ kms^{-1}pc^{-1}
- Age: 18 Myr
- No error analysis

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Makarov 2007

- Track the times of ‘closest encounter` for 14 members
- Excludes β Pic (!) and HIP 29964
- Mean time of nearest approach: 22 ± 12 Myr
- Weak expansion and larger scatter

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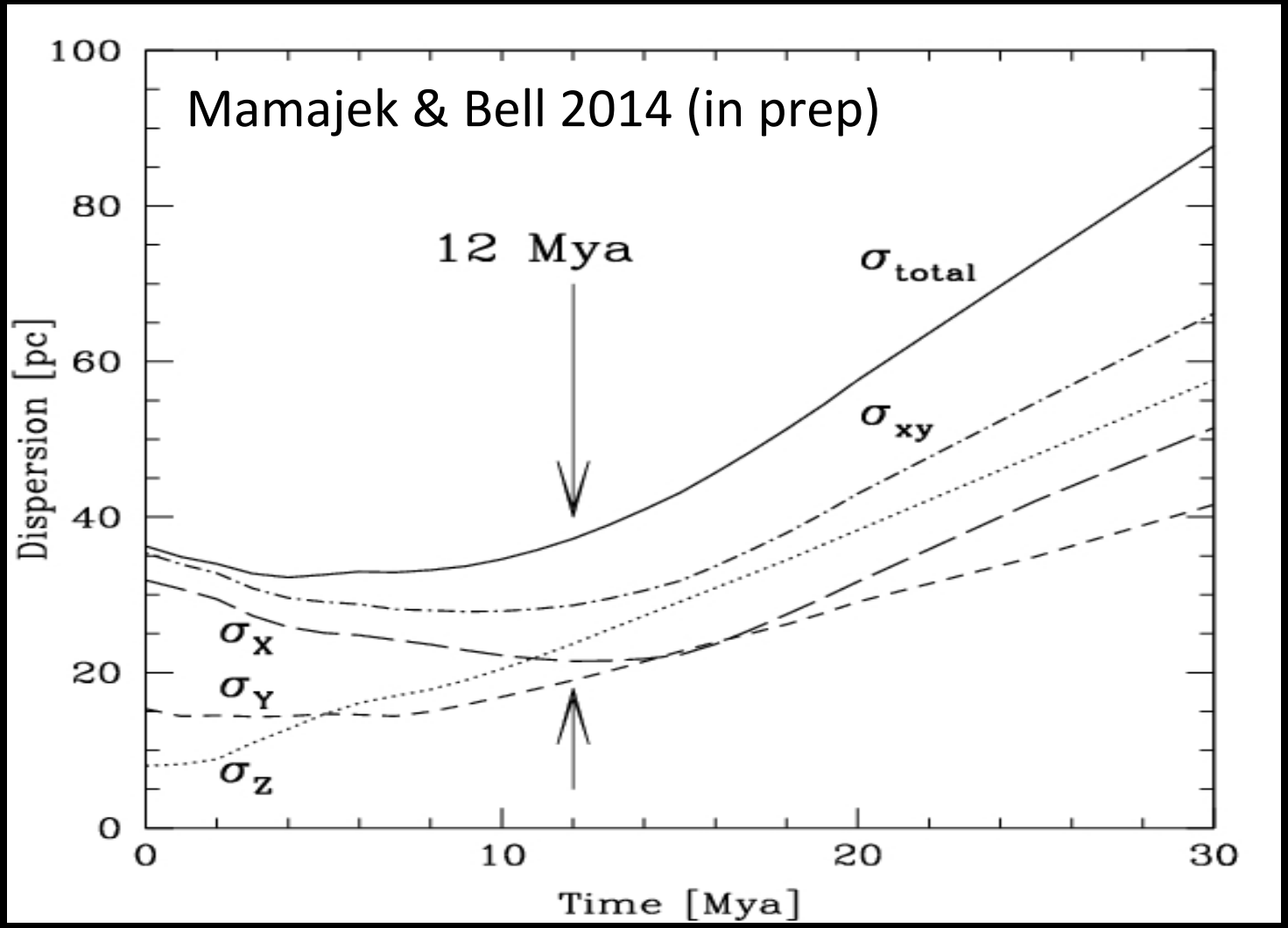
In light of new results…



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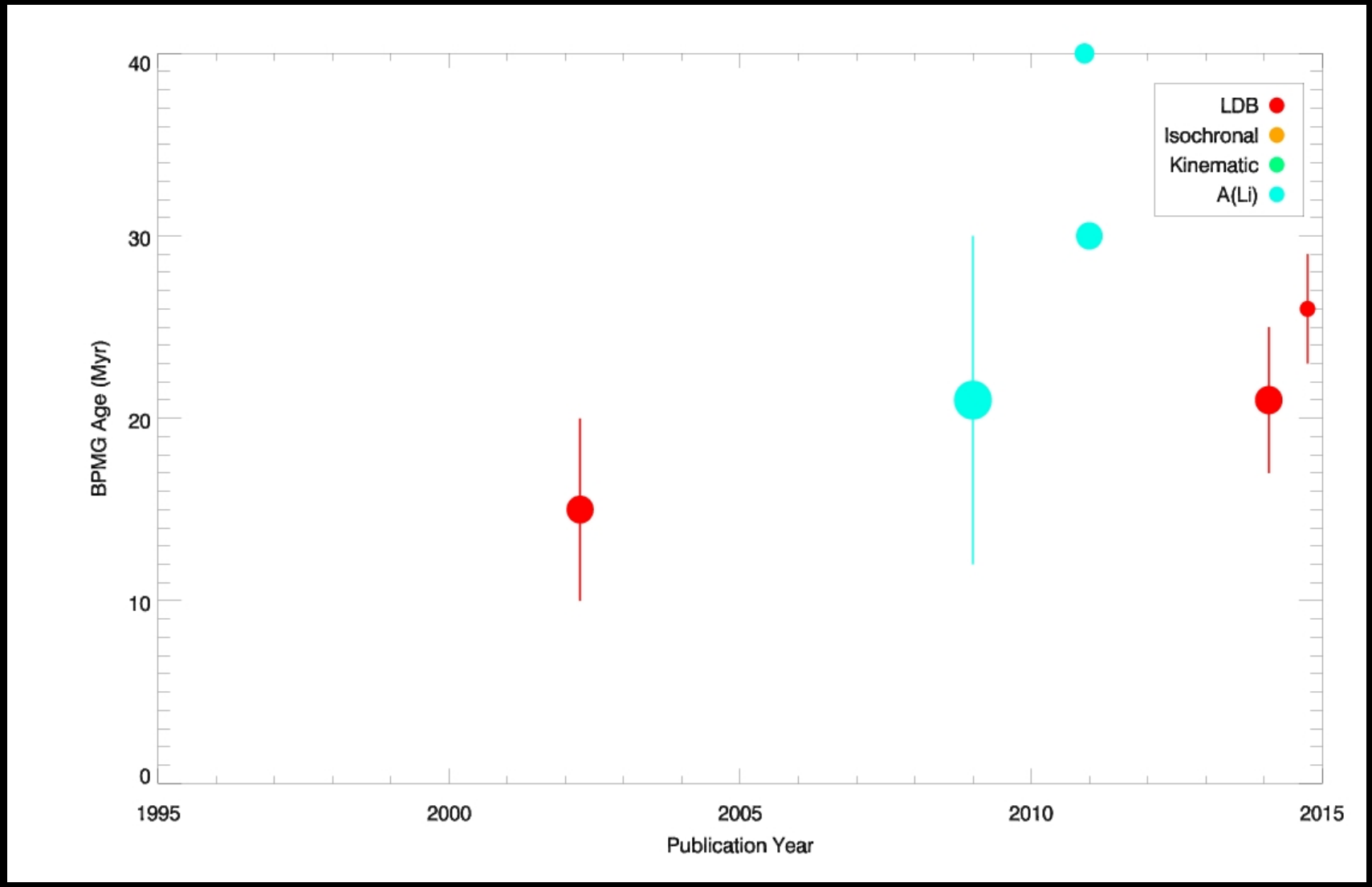
LDB (and Li depletion) ages



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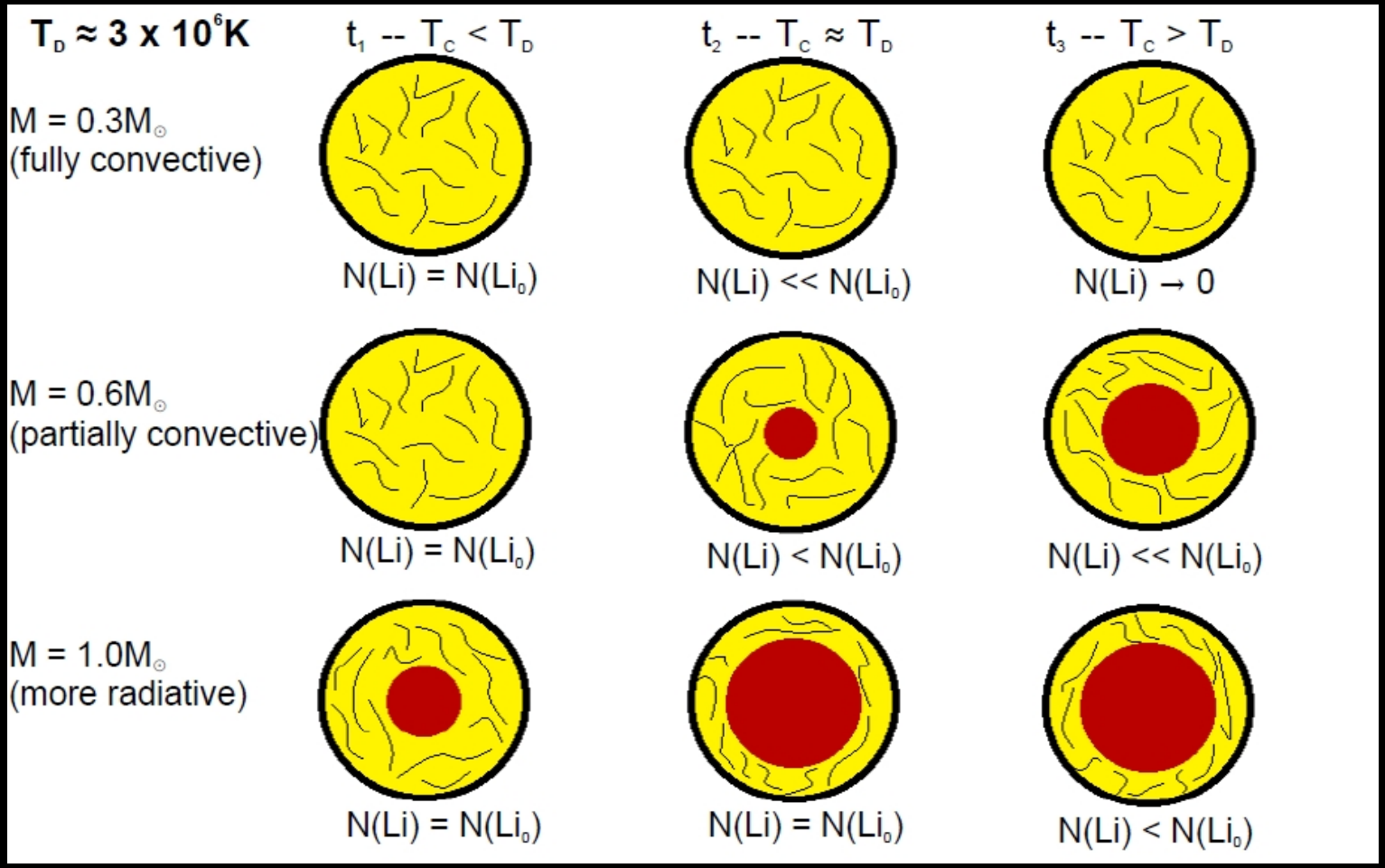
LDB technique



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Song et al. 2002

- Visual binary system HIP112312AB
- Li-rich object (M4.5)
- Li-poor object (M4.0)
- LDB age: 15 ± 5 Myr

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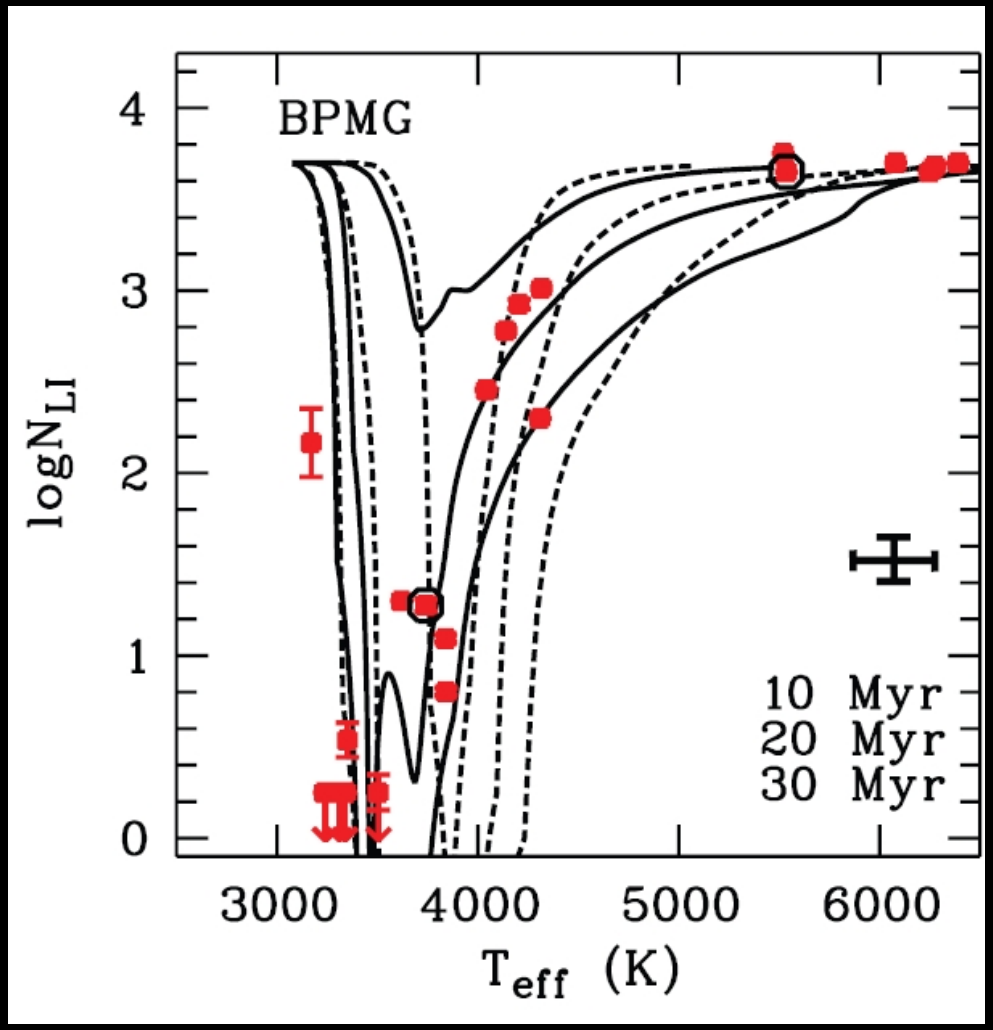
Li Depletion: Mentuch et al. 2008 and Yee & Jensen 2010



- Both use FGKM stars
- Both use T_{eff} in the models
- Mentuch: 21 ± 9 Myr
- Yee: ≈ 30 Myr

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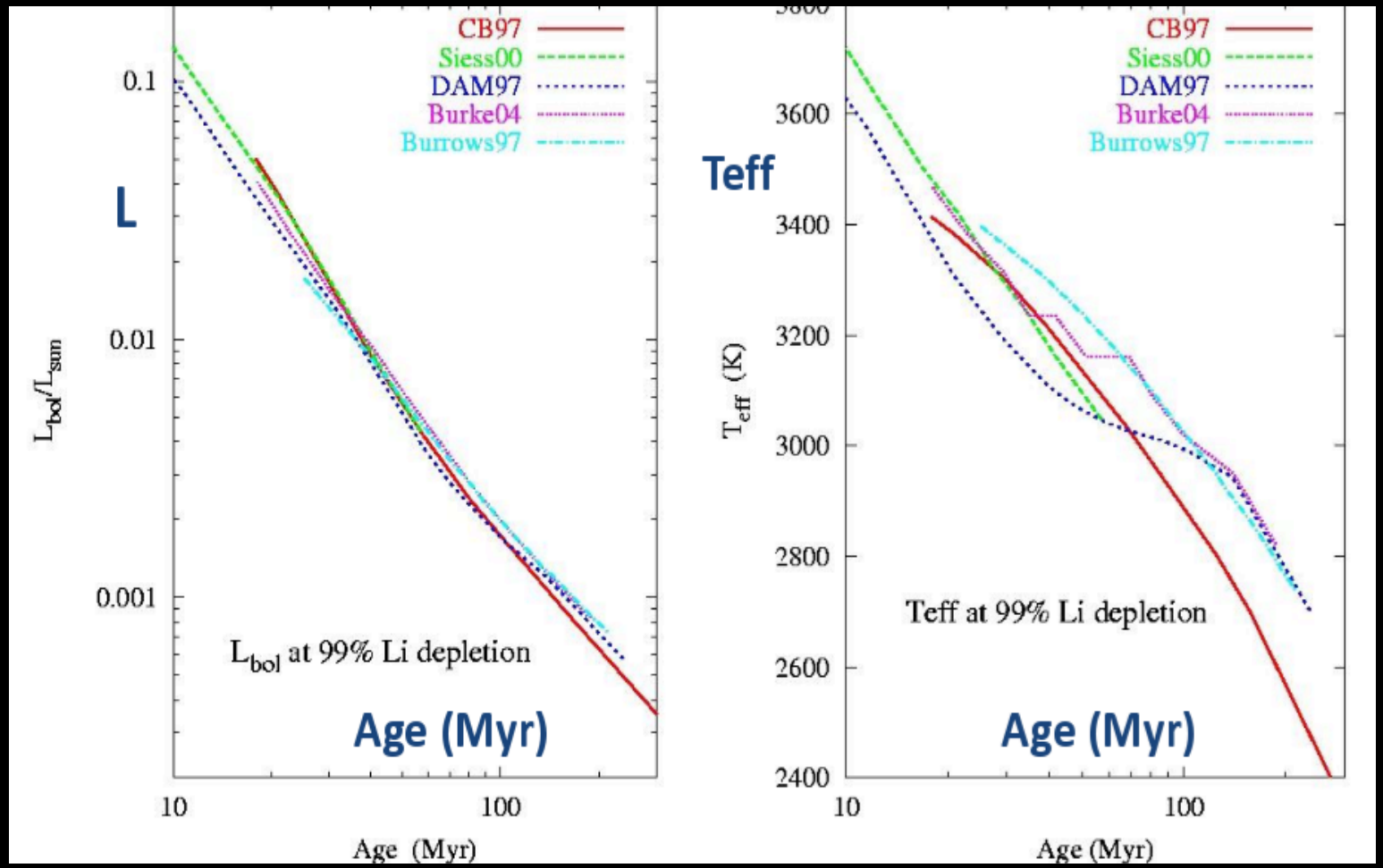
Model dependency of the LDB



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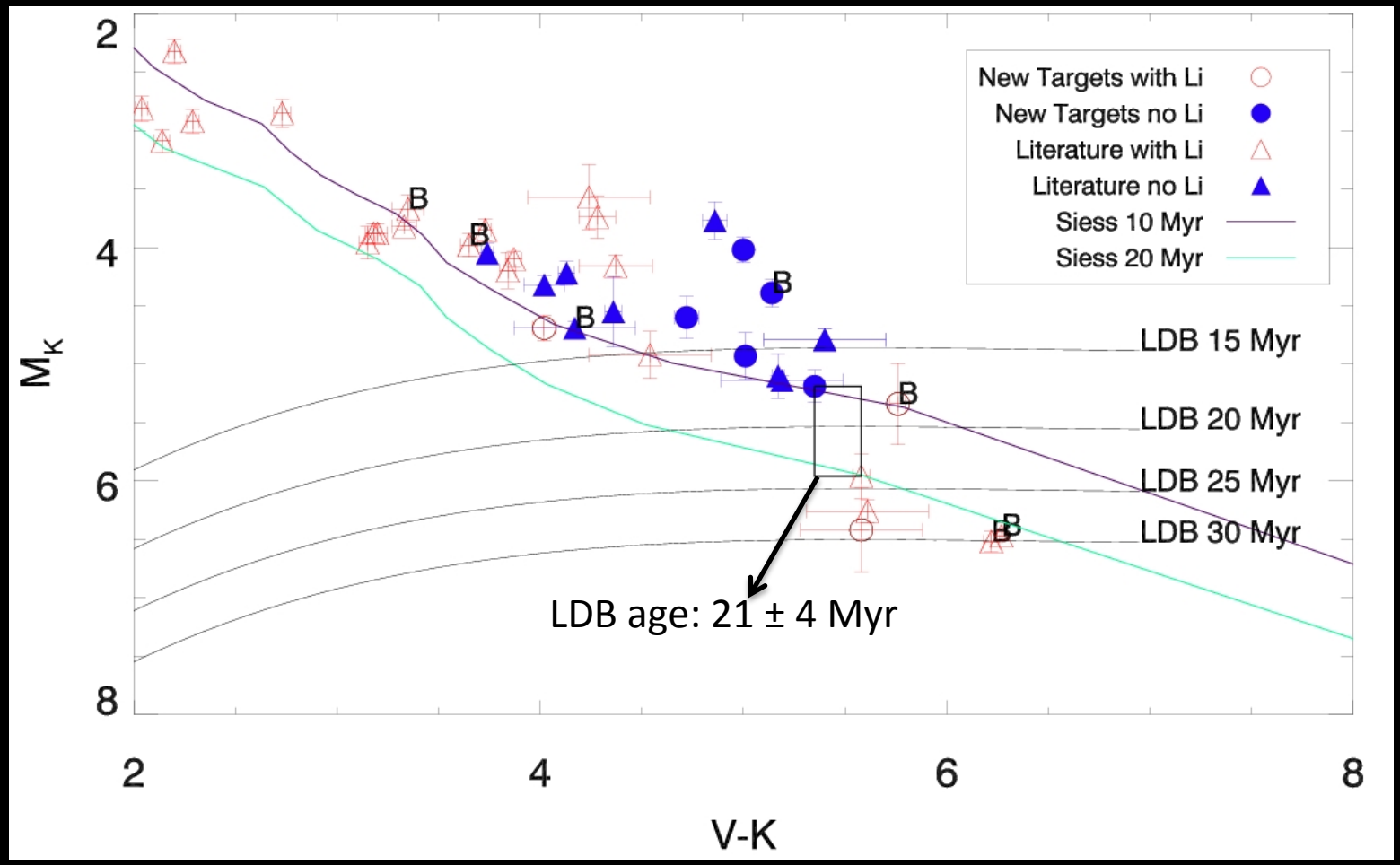
Binks & Jeffries 2014



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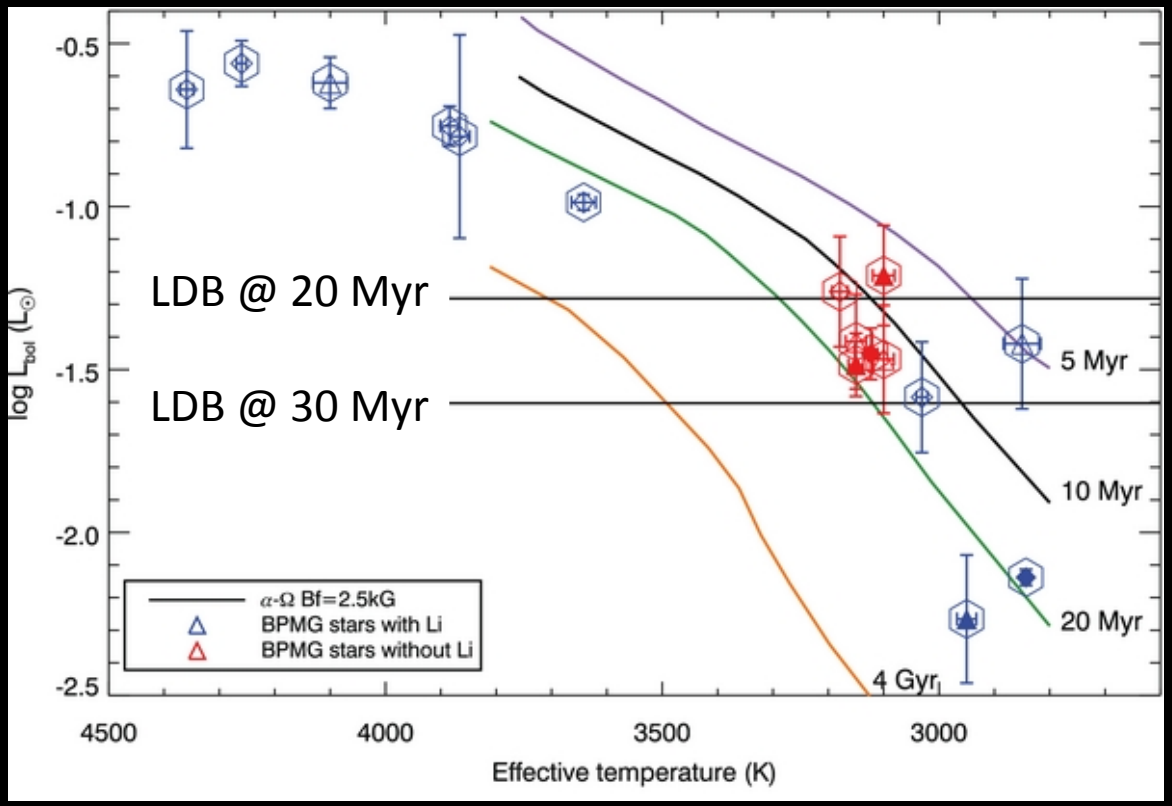
Malo et al. 2014



- Identify LDB at 99% depletion
- Use magnetic Dartmouth models
- LDB age: 26 ± 3 Myr

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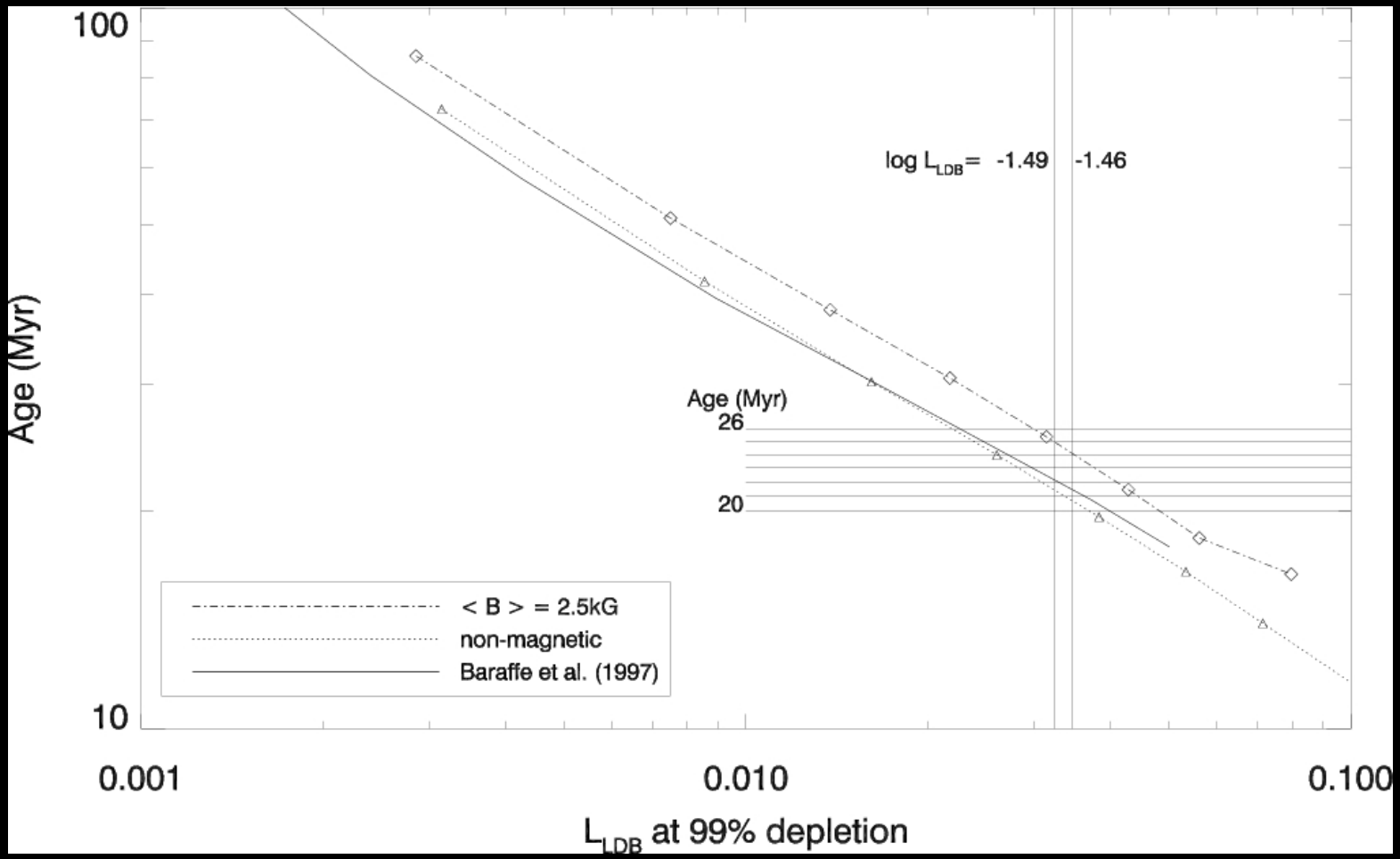
Binks & Jeffries 2014:
21 ± 4 Myr, logL = -1.46

LDB comparisons

Malo et al. 2014:
26 ± 3 Myr, logL = -1.49



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Binks & Jeffries 2014:
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LDB comparisons

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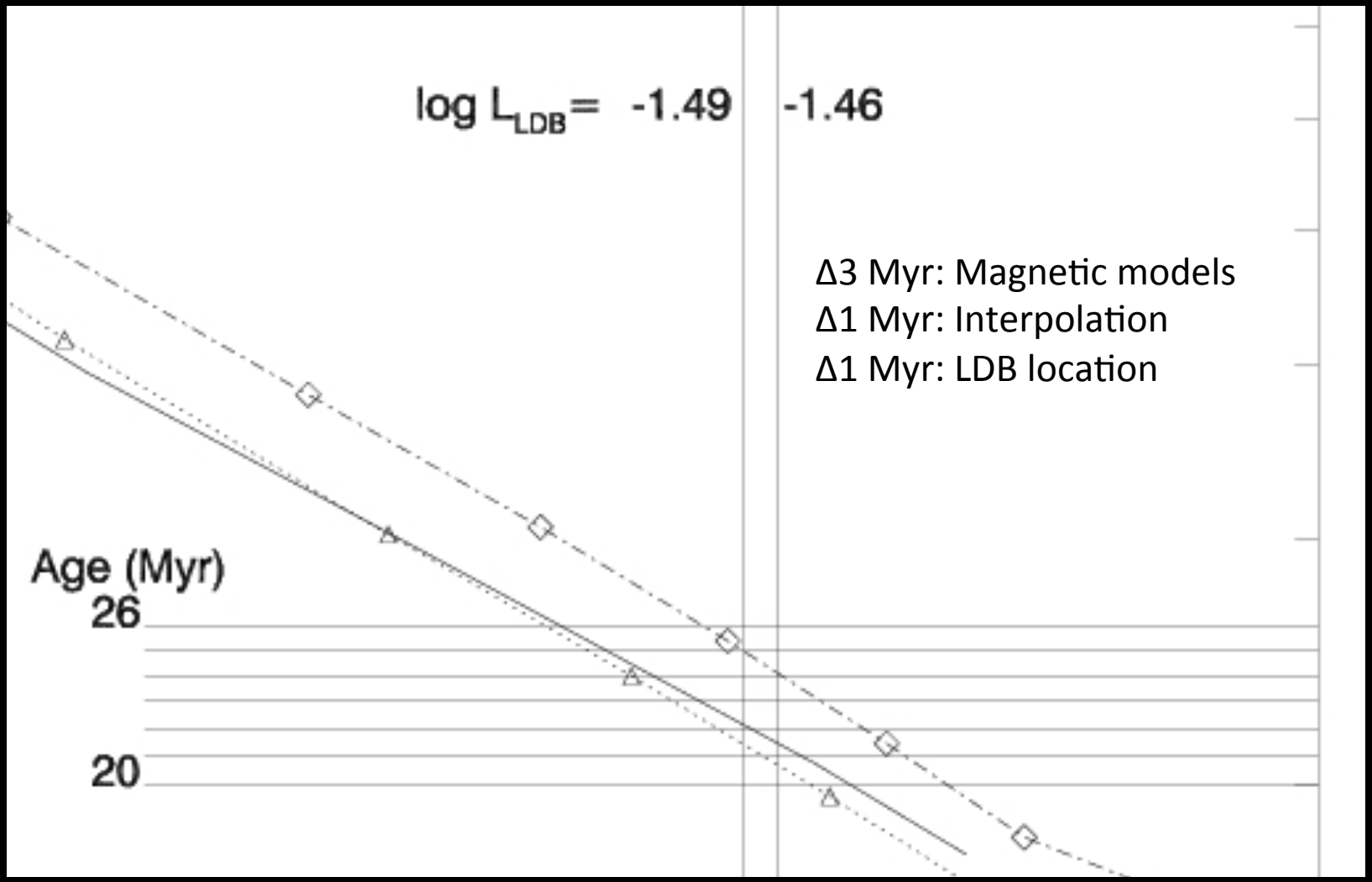

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So how old Is β Pic?

- Recent isochronal ages suggest β Pic is about double the Zuckerman et al 2001 age
- Kinematic ages are 'model-independent`, but potentially hazardous due to astrometry errors and sample choice – GAIA?
- LDB suggests an age of 20 – 25 Myr
- Combining all age estimates: **23 ± 4 Myr**

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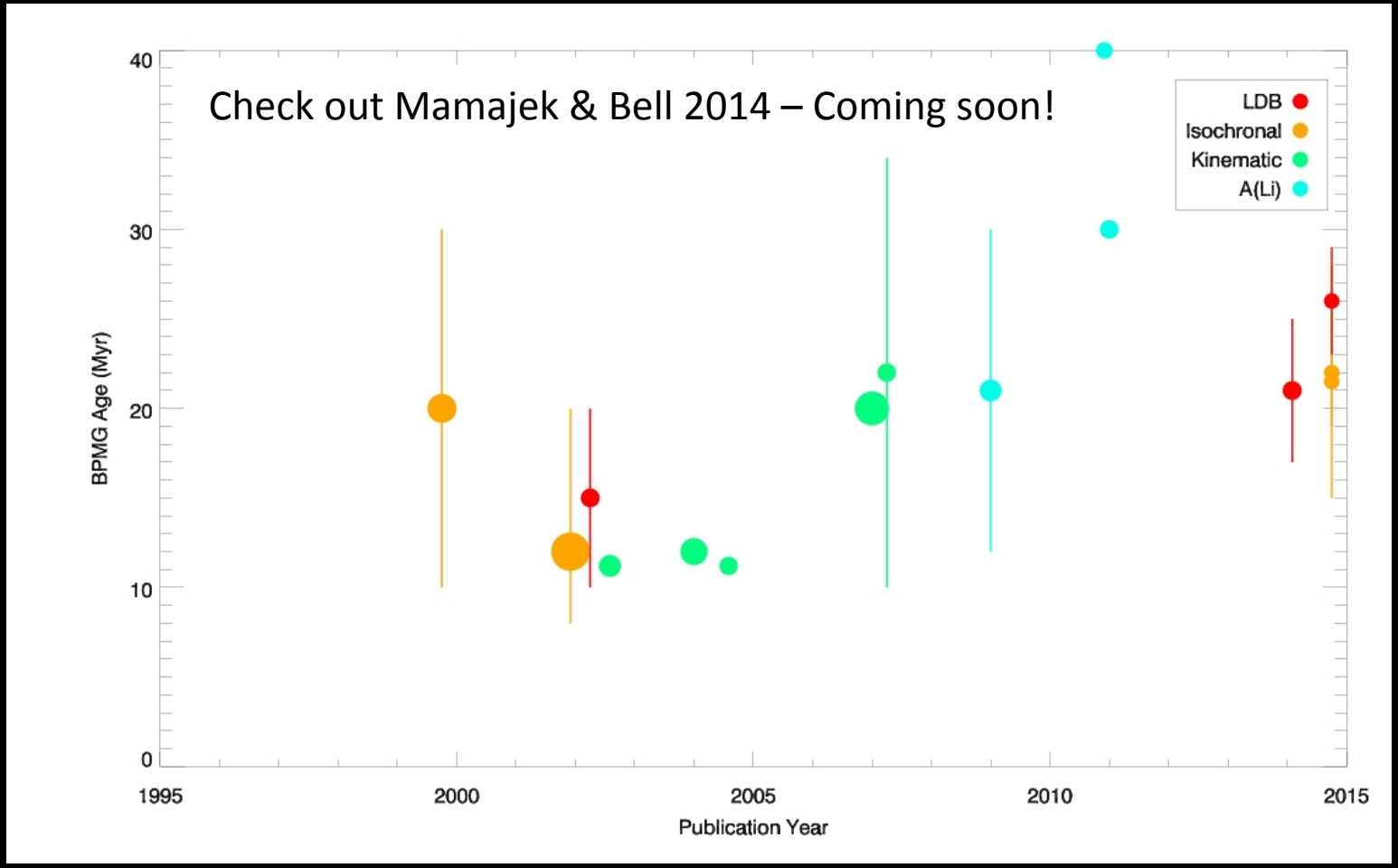
Thanks for listening!



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References

Paresce (1991), A&A, 247, 1

Jura et al. (1993), ApJL, 418, L37

Lanz et al. (1995), ApJL, 447, L41

Brunini et al. (1996), MNRAS, 283, L84-L88

Crifo et al. (1997), Conf Prod, 437-440

Barrado (1998), Astrophysics and Space Science, 263, 235

Barrado et al. (1999), ApJ, 520, L123-L126

Zuckerman et al. (2001), ApJ, 562, L87-L90

Ortega et al. (2002), ApJ, 575, 75

Song et al. (2002), ApJ, 581, 43

Song et al. (2003), ApJ, 599, 342

Ortega et al. (2004), ApJ, 609, 243

Torres et al. (2006), A&A, 460, 695

Makarov et al. (2007), ApJ, 658, 480

Mentuch et al. (2008), ApJ, 689, 1127

Yee & Jensen (2010), ApJ, 711, 303

Malo et al. (2014), ApJ,

Binks & Jeffries (2014), MNRAS, 438, 11

Malo et al. (2014), ApJ, 792, 37

Mamajek & Bell (2014, in prep)

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