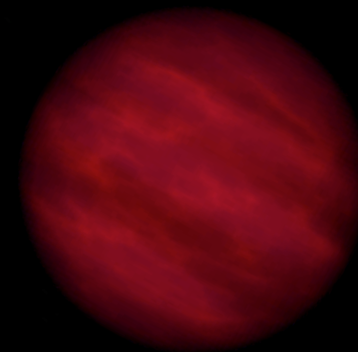
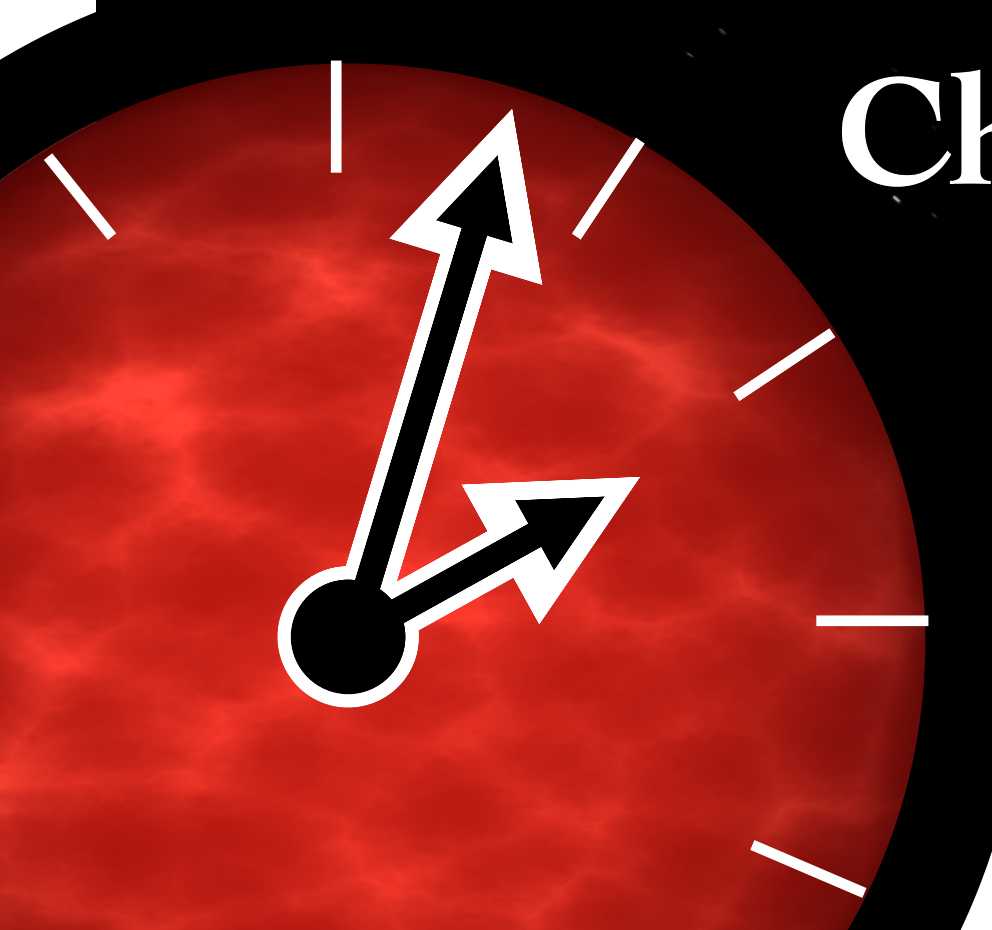


Brown Dwarfs as Galactic Chronometers



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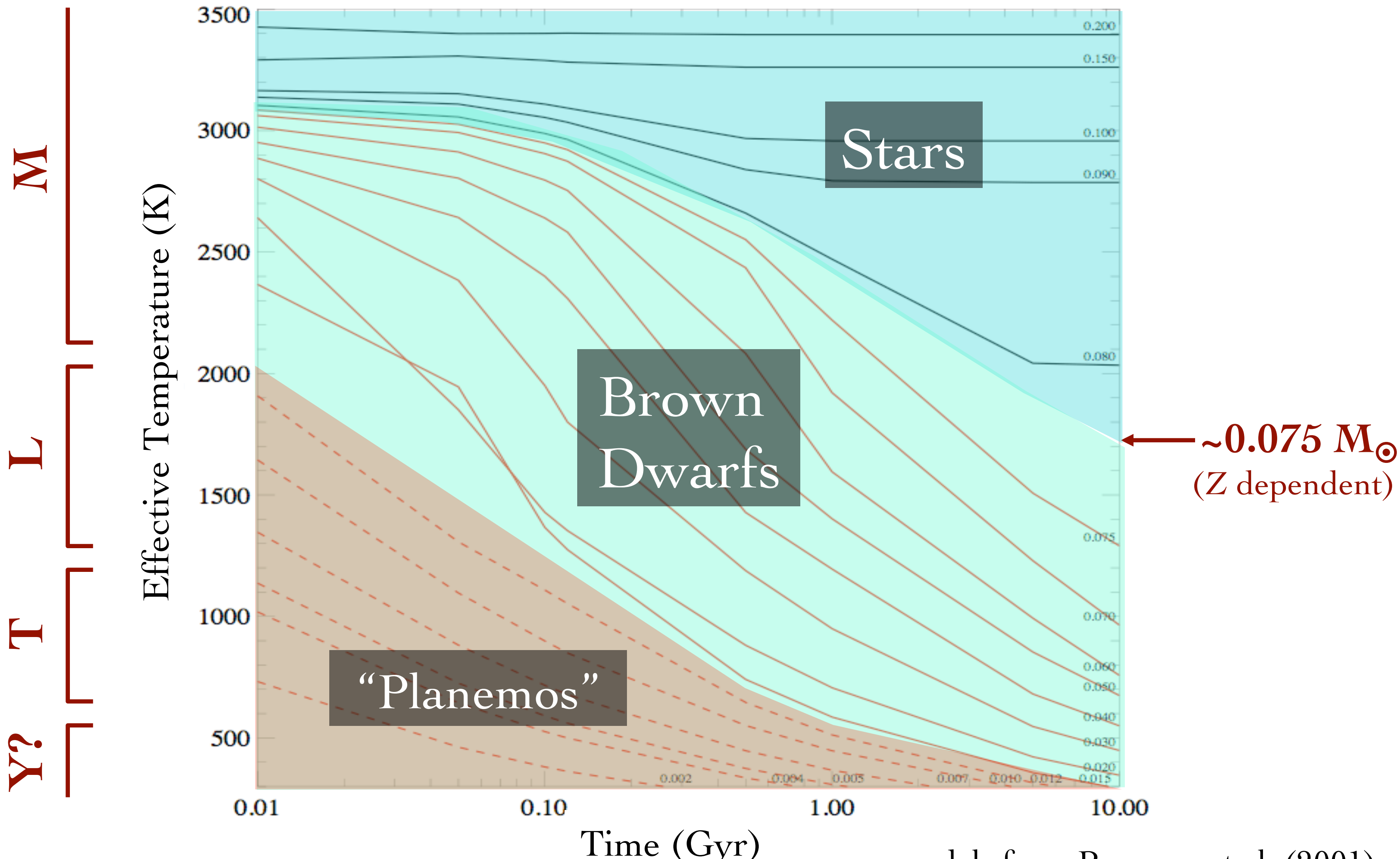
Spectral classes



models from Burrows et al. (2001)

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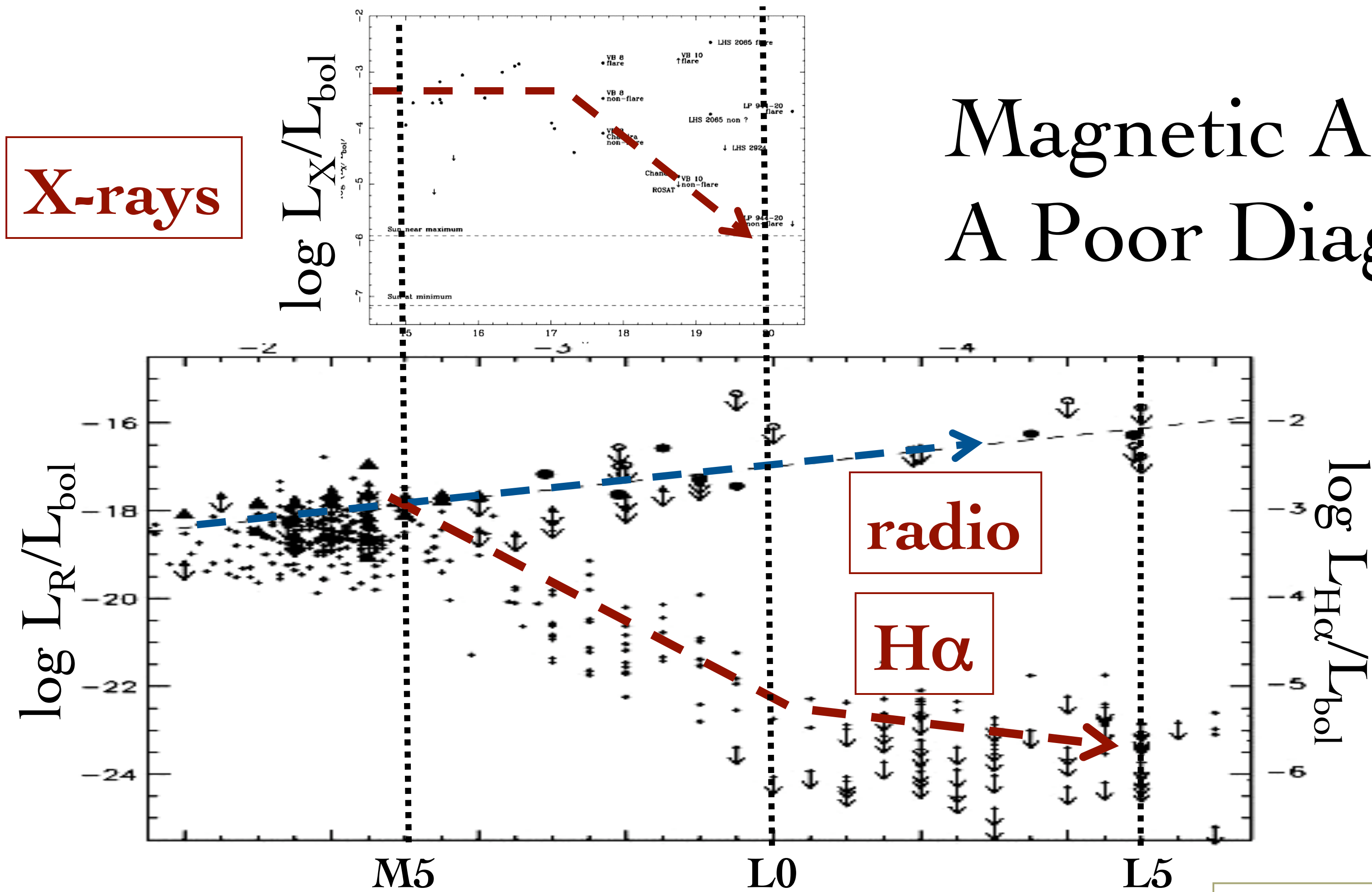
Magnetic Activity: A Poor Diagnostic



(next) talk by A. West

Fleming et al. (2003); Burgasser & Putman (2006)
see also Gizis et al. (2000); West et al. (2004); Osten et al. (2005); Berger (2006); Audard et al. (2007); Schmidt et al. (2007)

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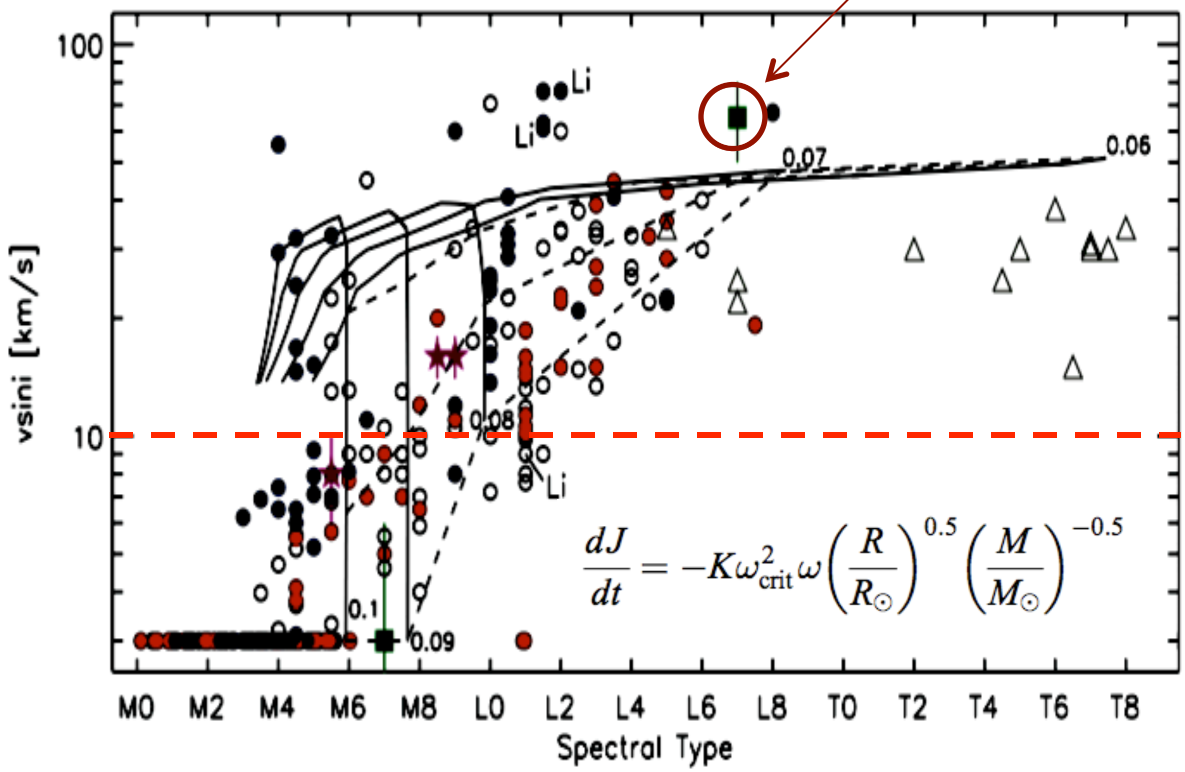
Do Brown Dwarfs ever spin down?

Halo L subdwarf vsini = 65 km/s



No slow rotators for SpT > L2, evidence of mass & temperature dependent spindown timescale ($\omega_{crit} \rightarrow 0$).

Reiners & Basri (2008)

see also Mohanty et al. (2002), Mohanty & Basri (2003), Bailer-Jones (2004); Reiners & Basri (2006), Blake et al. (2007)

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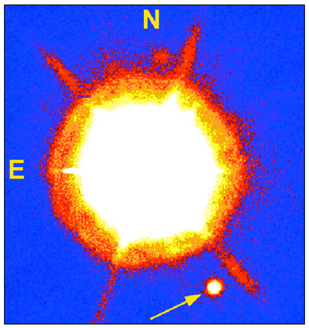
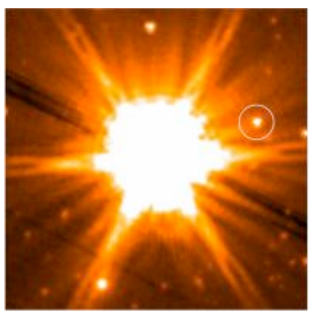
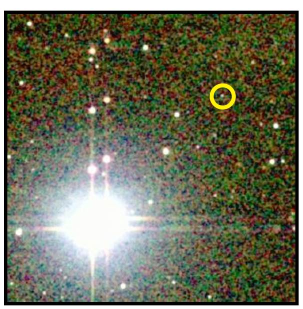
Method 1: Companions and Clusters



G 196-3B (30-300 Myr)
Rebolo et al. (1998)

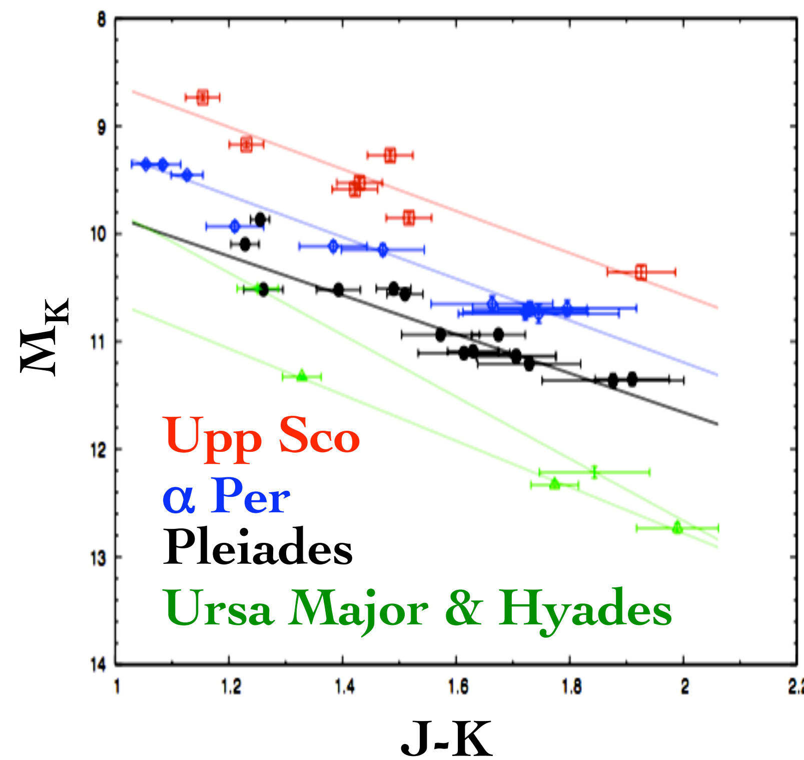


HD 3651B (0.7-4.7 Gyr)
Luhman et al. (2006)
Mugrauer et al. (2006)



Gliese 570D (2-5 Gyr)
Burgasser et al. (2000)

Young clusters



Jameson et al. (2008)

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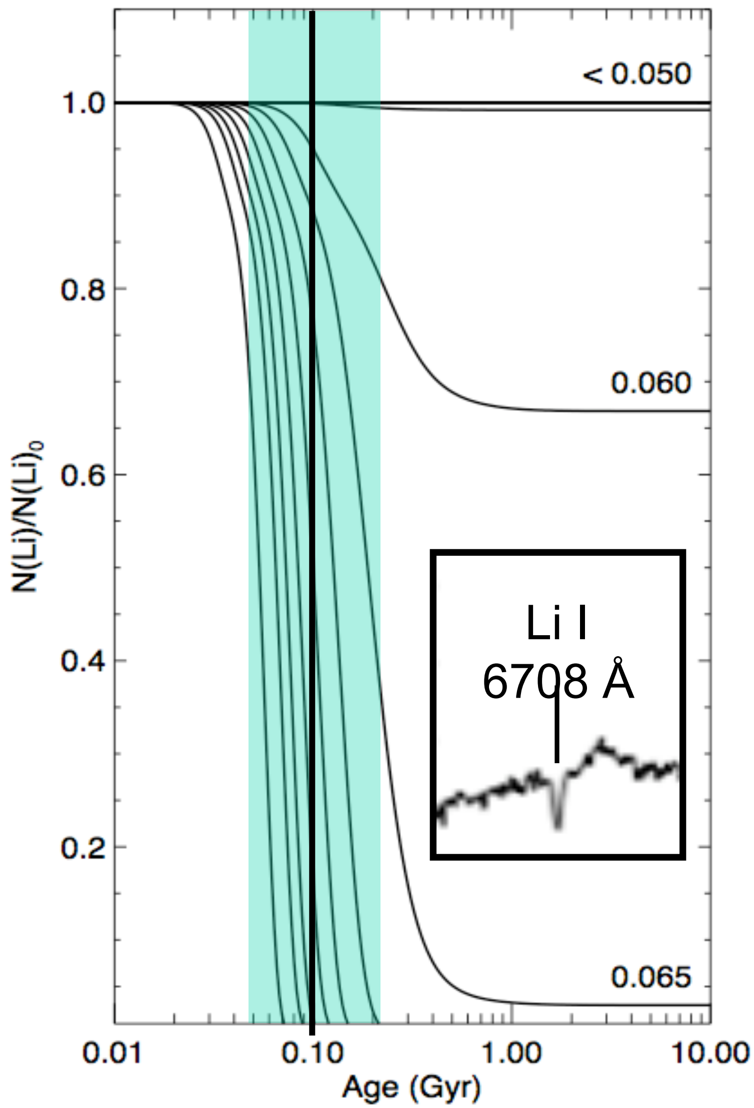
models from Burrows et al. (2001)



Method 2: The Li clock

Li is fused to exhaustion in the core for $M > 0.065\ M_\odot$, ages > 500 Myr

50-200 Myr "sweet spot": degree of Li depletion depends on age and mass - the **Li depletion boundary**.

see Rebolo et al. (1992); Bildsten et al. (1997)

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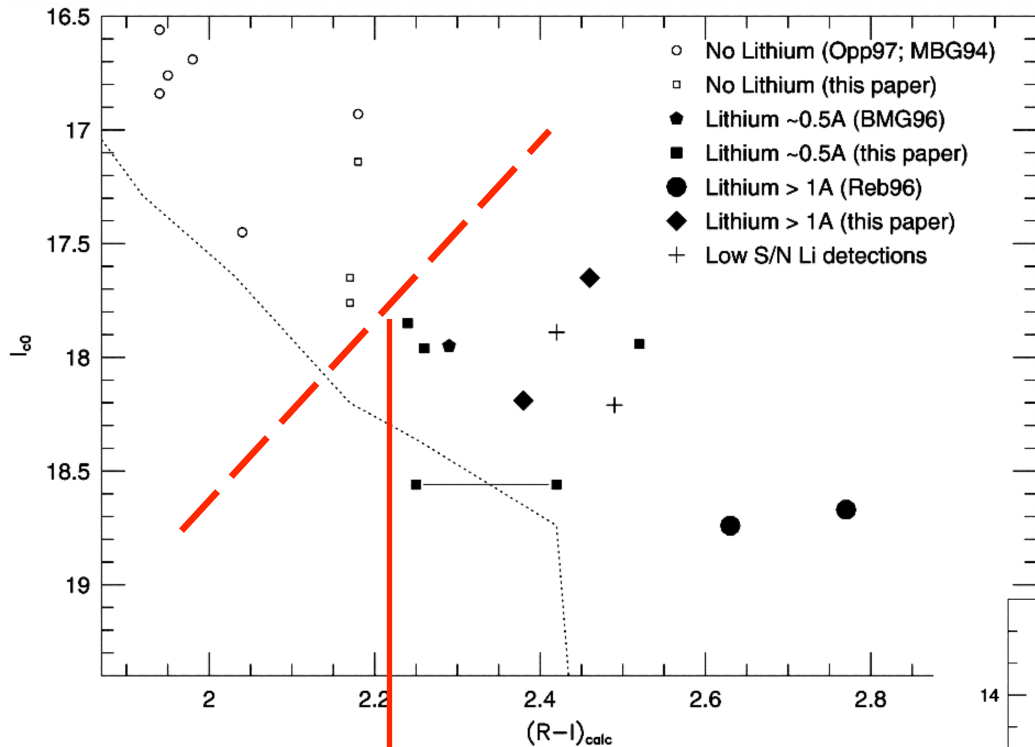
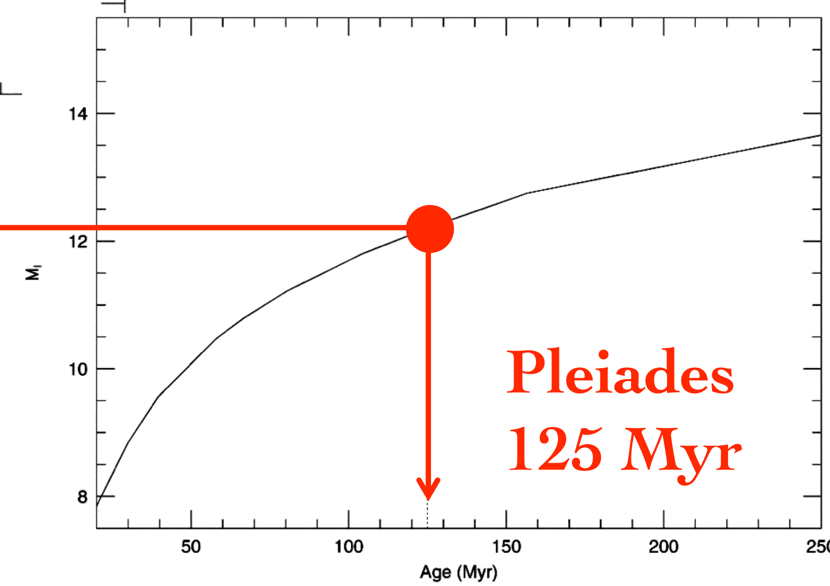


Luminosity at which Li I line disappears can be matched to a corresponding mass & age



Stauffer et al. (1998)

see also Barrado y Navascués et al. (1999); Stauffer et al. (1999); Oliveira et al. (2003); Manzi et al. (2008)

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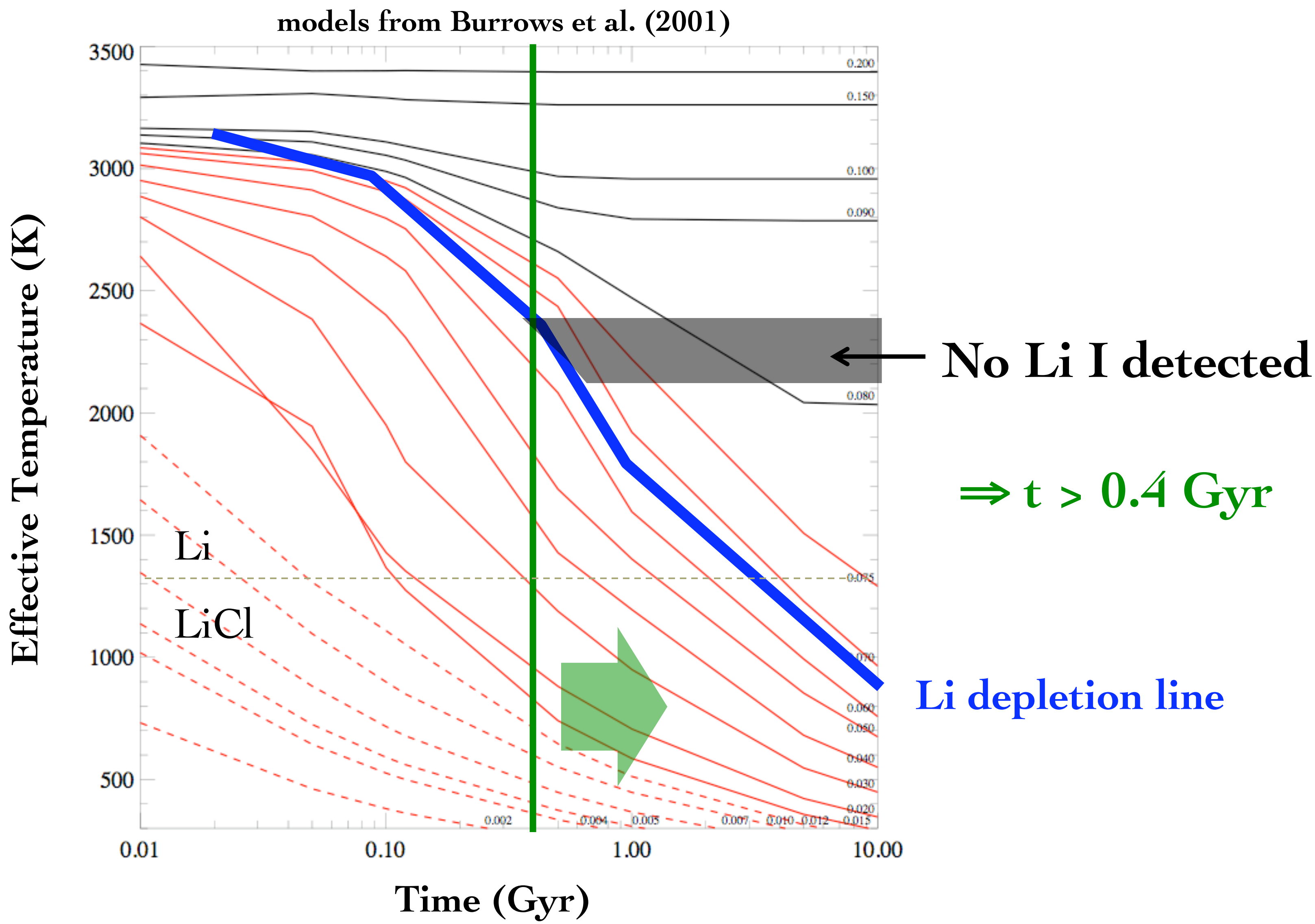

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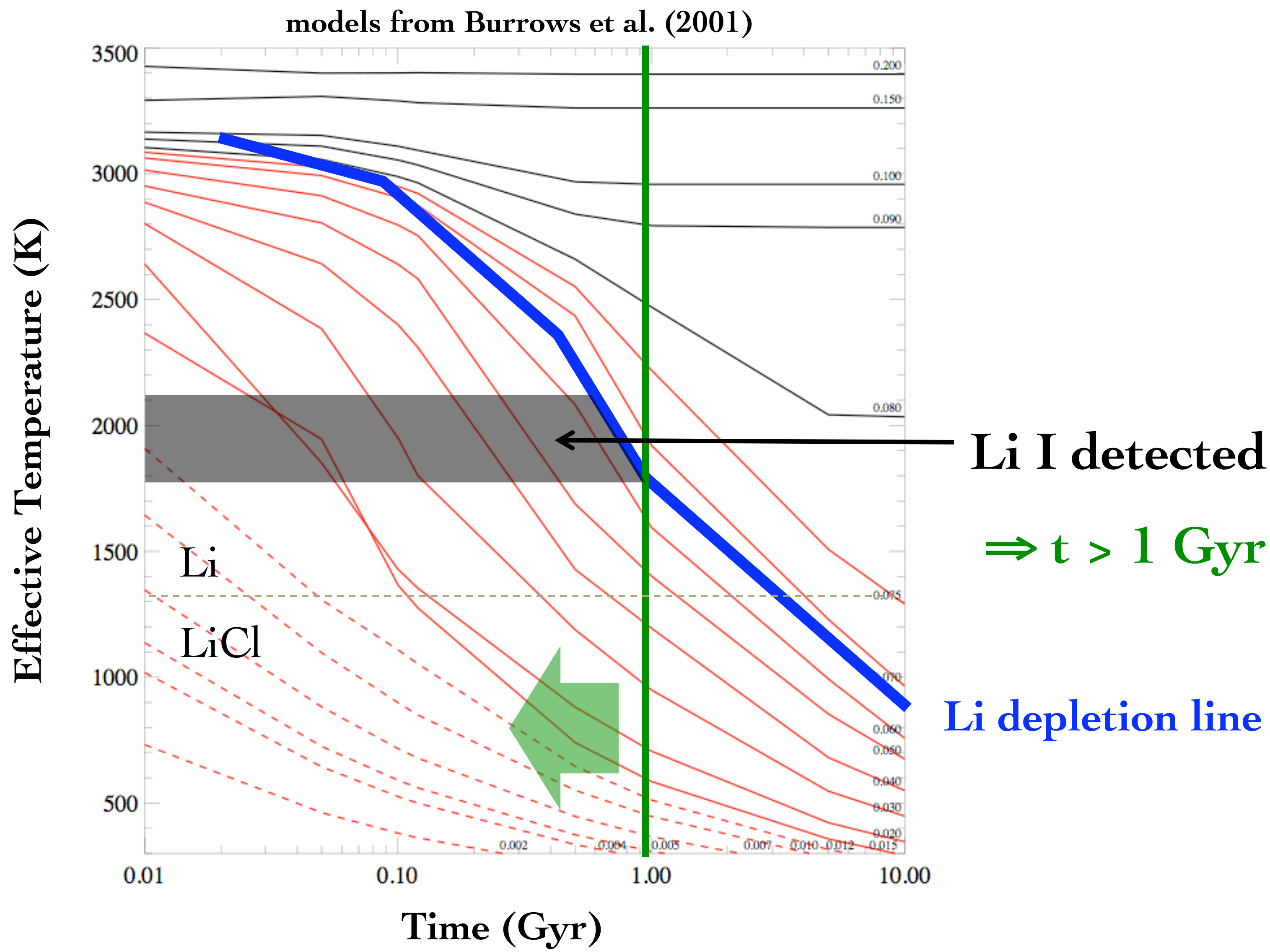

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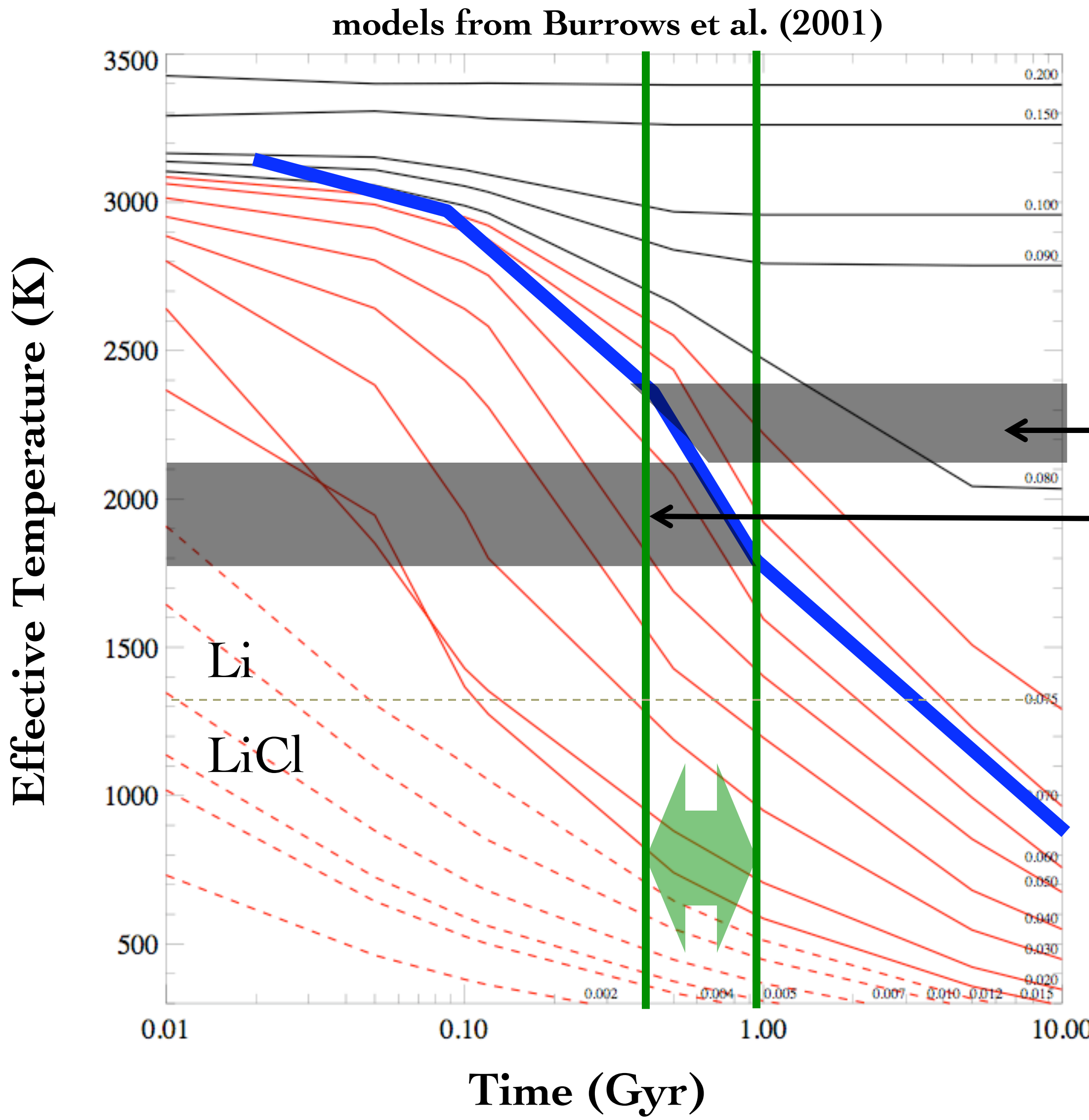
A Li clock Binary



No Li I detected

Li I detected

⇒ 0.4 < t < 1 Gyr

Li depletion line

see Liu & Leggett (2005); Burgasser et al. (2005); Zapatero Osorio et al. (2008)

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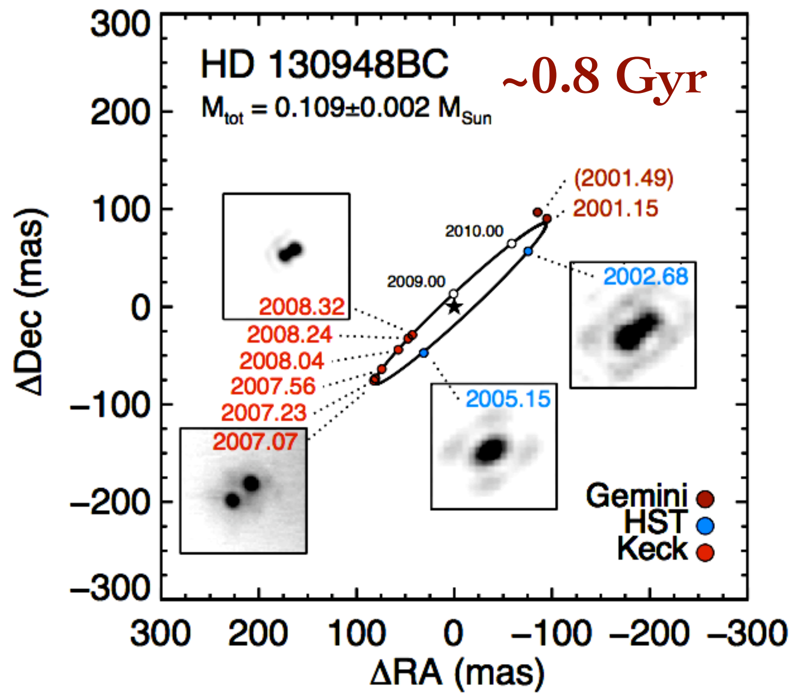
Method 3: Mass Standards

A growing number of brown dwarf binaries have orbital (dynamic) mass measurements.

Binary companions to age-dated stars/in clusters provide **tests of evolutionary models**.



Talk by T. Dupuy, Poster by M. Liu

Dupuy, Liu & Ireland (2008)

see also Lane et al. (2001), Bouy et al. (2004); Zapatero Osorio et al. (2004); Stassun et al. (2006); Bouy et al. (2008); Liu et al. (2008)

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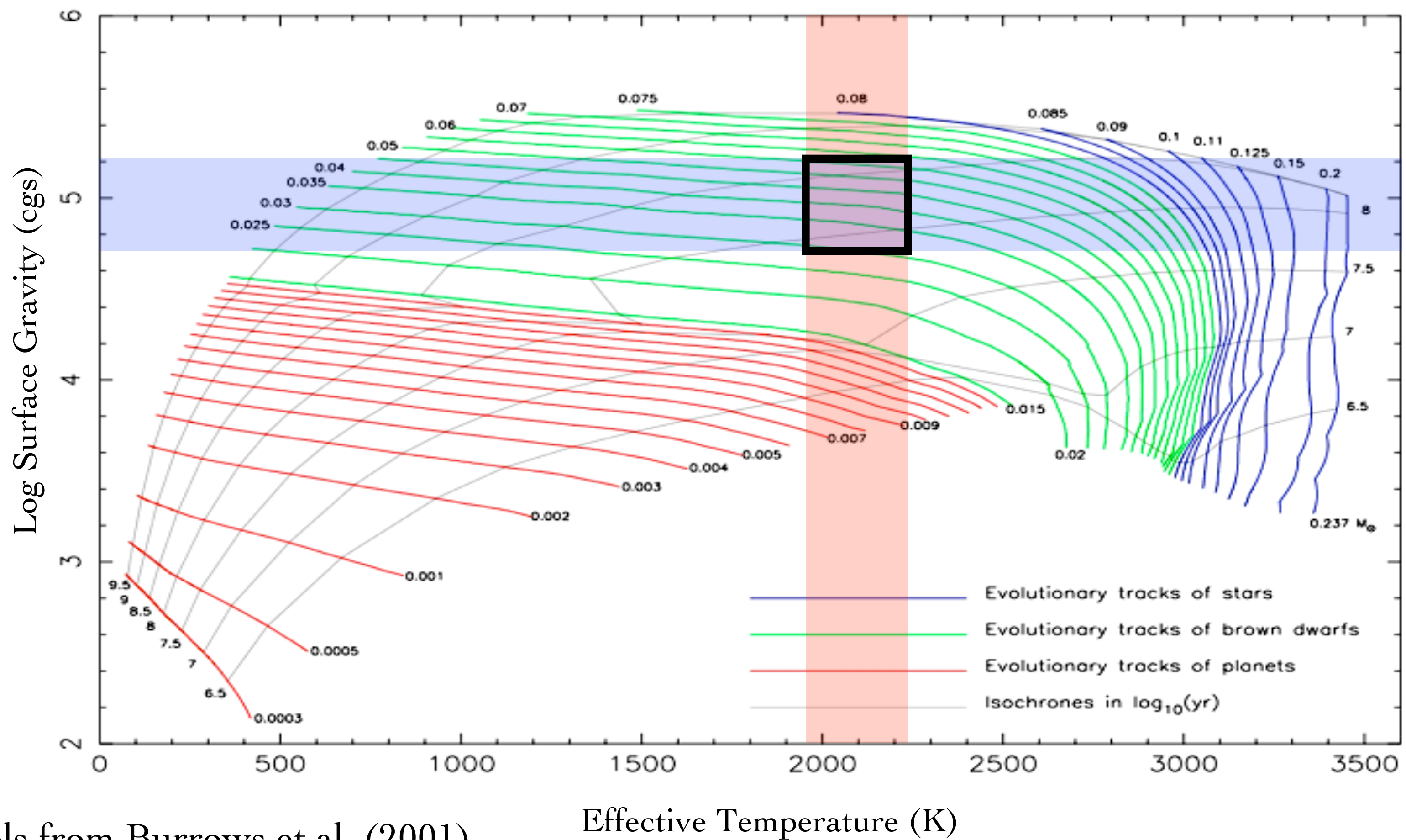
Method 4: Surface Gravity



models from Burrows et al. (2001)

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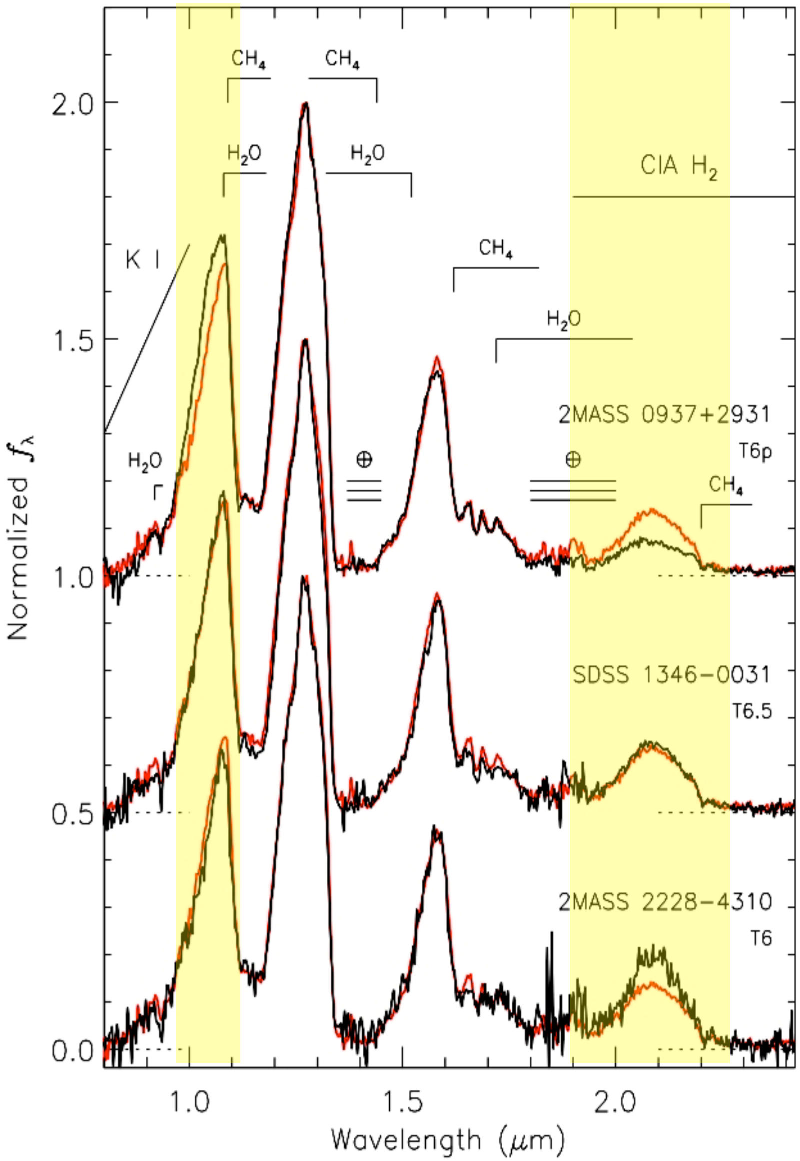

Surface Gravity Diagnostics

T_{eff} & gravity → mass & age can be made for individual field objects

Caveat: metallicity

Burgasser, Burrows & Kirkpatrick (2006)

see also Knapp et al. (2004); Burgasser (2007); Liebert & Burgasser (2007); Liu et al. (2007); Looper et al. (2007); Warren et al. (2007); Delorme et al. (2008); Leggett et al. (2008); Burningham et al. (2008)

Poster by S. Leggett

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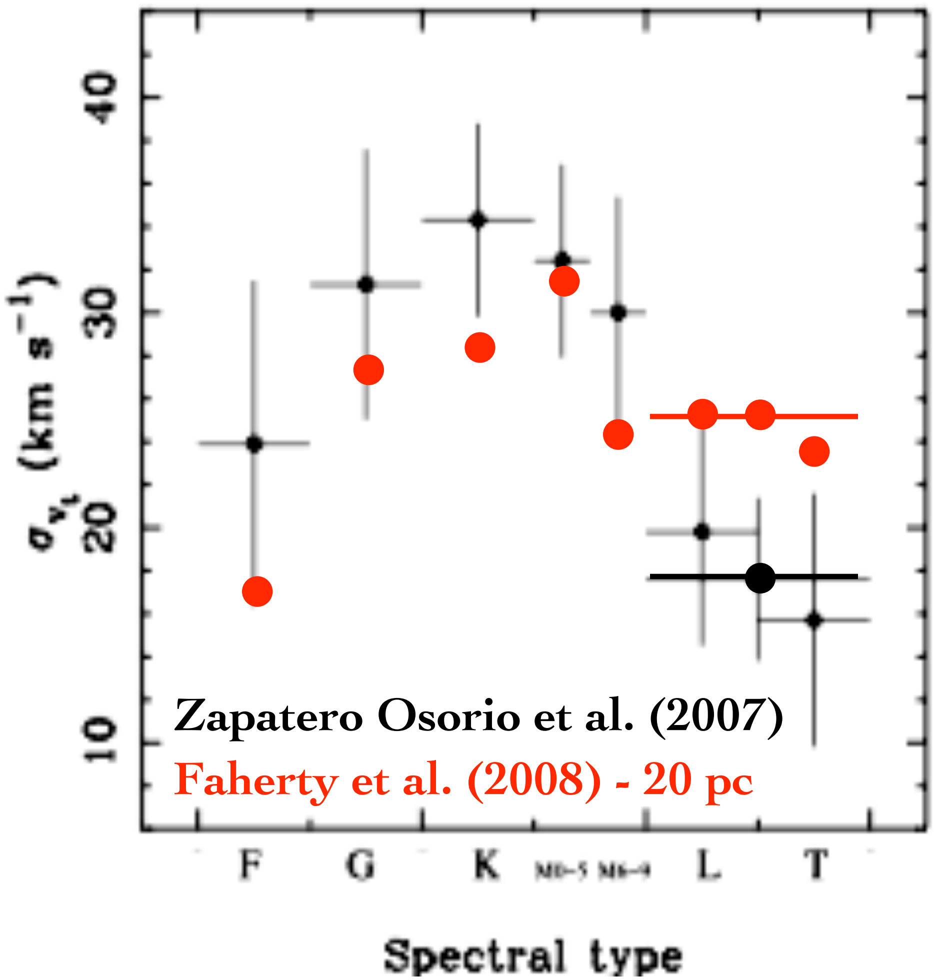

Method 5: Kinematics

Are local brown dwarfs young?

Zapatero Osorio et al. (2007): 21 L & T dwarfs w/ UVW ⇒ <age> ~ 0.5-4 Gyr

Faherty et al. (2008): >800 M7-T8 dwarfs w/ V_{tan} ⇒ <age> ~ 3-8 Gyr

see also Schmidt et al. (2007); Jameson et al. (2007); Casewell et al. (2008)

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Cluster members & companions - distant and/or rare, can encompass any spectral type, useful benchmarks

Li clock - optimal for 50-200 Myr & resolved binaries (rare); limits for T_{eff} > 1300 K (M and L dwarfs)

Mass standards - very rare, long-term time investment, critical for testing models, challenging benchmarks

Surface gravity - useful in principle any source, ideal for T dwarfs, requires benchmarks

Kinematics - appropriate for large samples, current results controversial (single sources caveat emptor)

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