Post common envelope binaries from SDSS:

Constraining the common envelope efficiency

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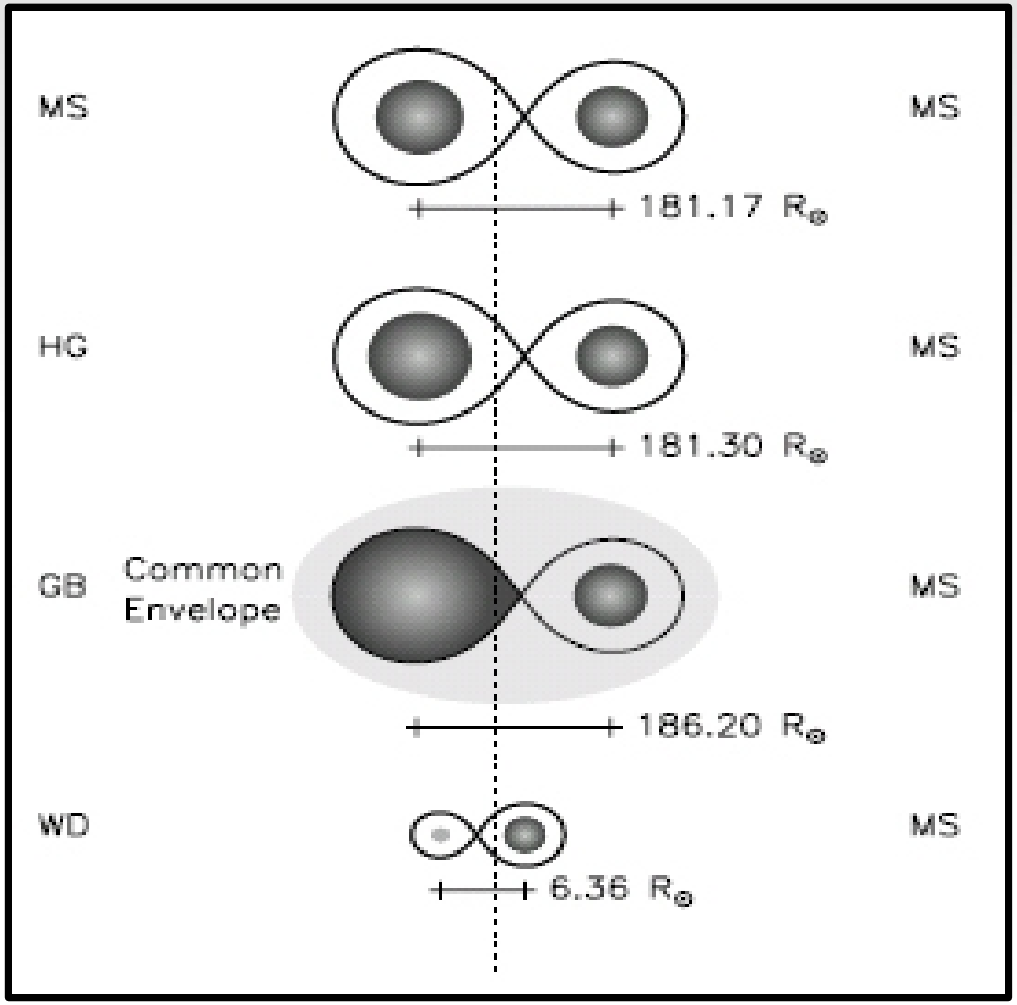
Outline

- Introduction:
  - Formation of close compact binaries
  - How to constrain close binary evolution with PCEBs
- The sample
- Our Code: First Results
- Summary

Formation of close compact binaries:
Standard Model



Willems & Kolb
2004

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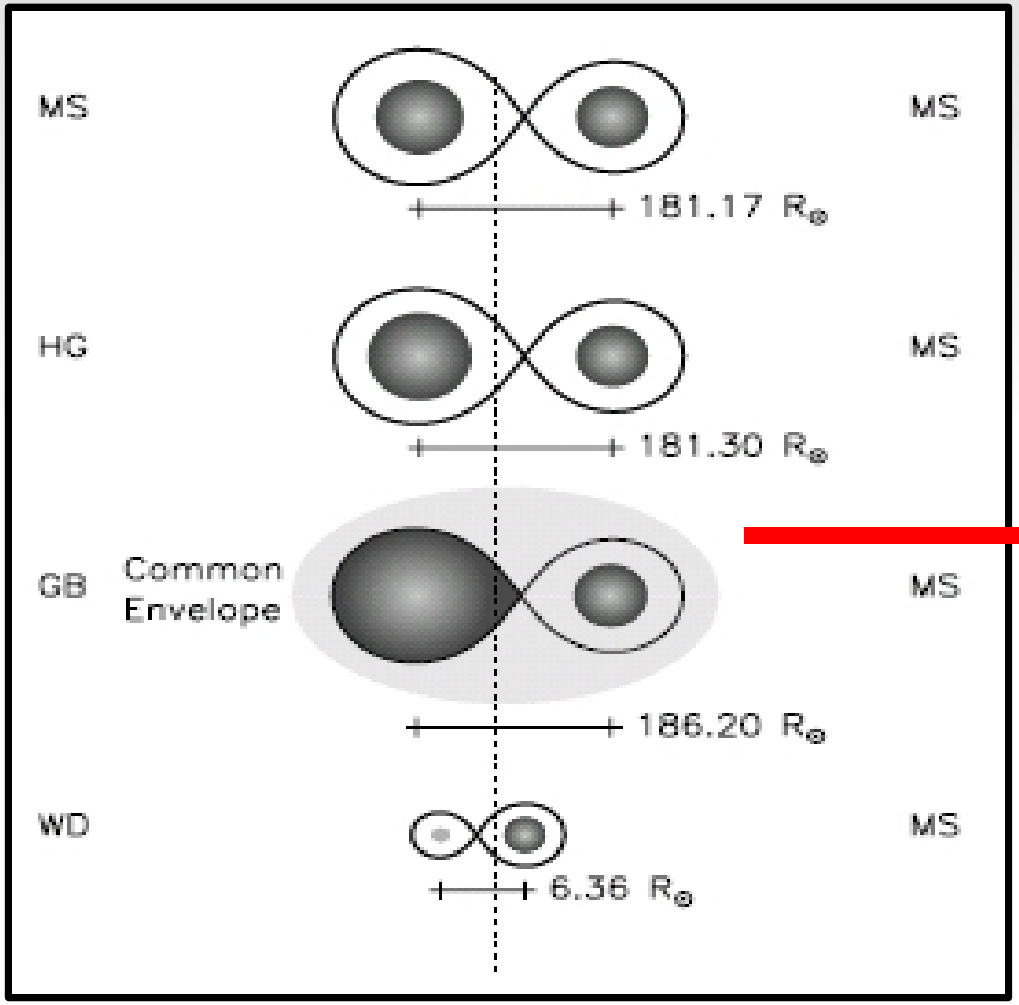
Standard Model



Scientists try to determine α_{CE} since thirty years

Willems & Kolb 2004

Constraining CE-evolution with PCEBs

- Determine the relation between the separation before and after the CE phase.

- Principal algorithm: **Energy conservation** (Paczynski 1976, standard α formalism)

$$\alpha_{\rm ce}\Delta E_{\rm orb} = E_{\rm gr}$$

generally approximated by

$$\frac{GM_{\rm g}M_{\rm e}}{\lambda R_{\rm g}} = \alpha\left(\frac{GM_{\rm c}m}{2a_{\rm f}} - \frac{GM_{\rm g}m}{2a_{\rm i}}\right)$$

λ → Structural parameter ~ 0.5
α → CE efficiency

Constraining CE-evolution with PCEBs

Nelemans & Tout 2005

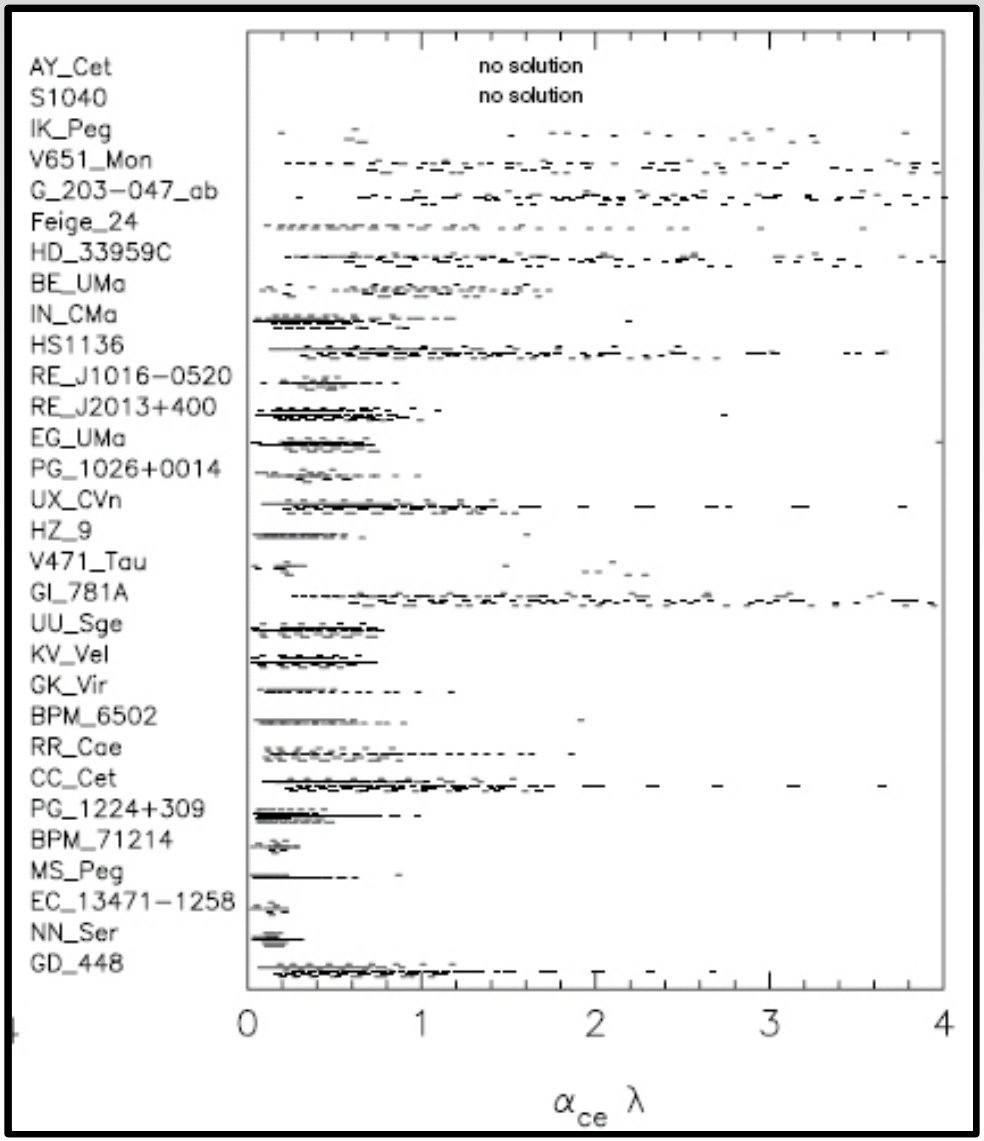
SSE code (Hurley et al. 2000)

For M_g between 1.0 and M_{max}

Assuming

- $R_g = R_L$ when $M_C = M_P$

Constraining CE-evolution with PCEBs



Nelemans & Tout (2005)

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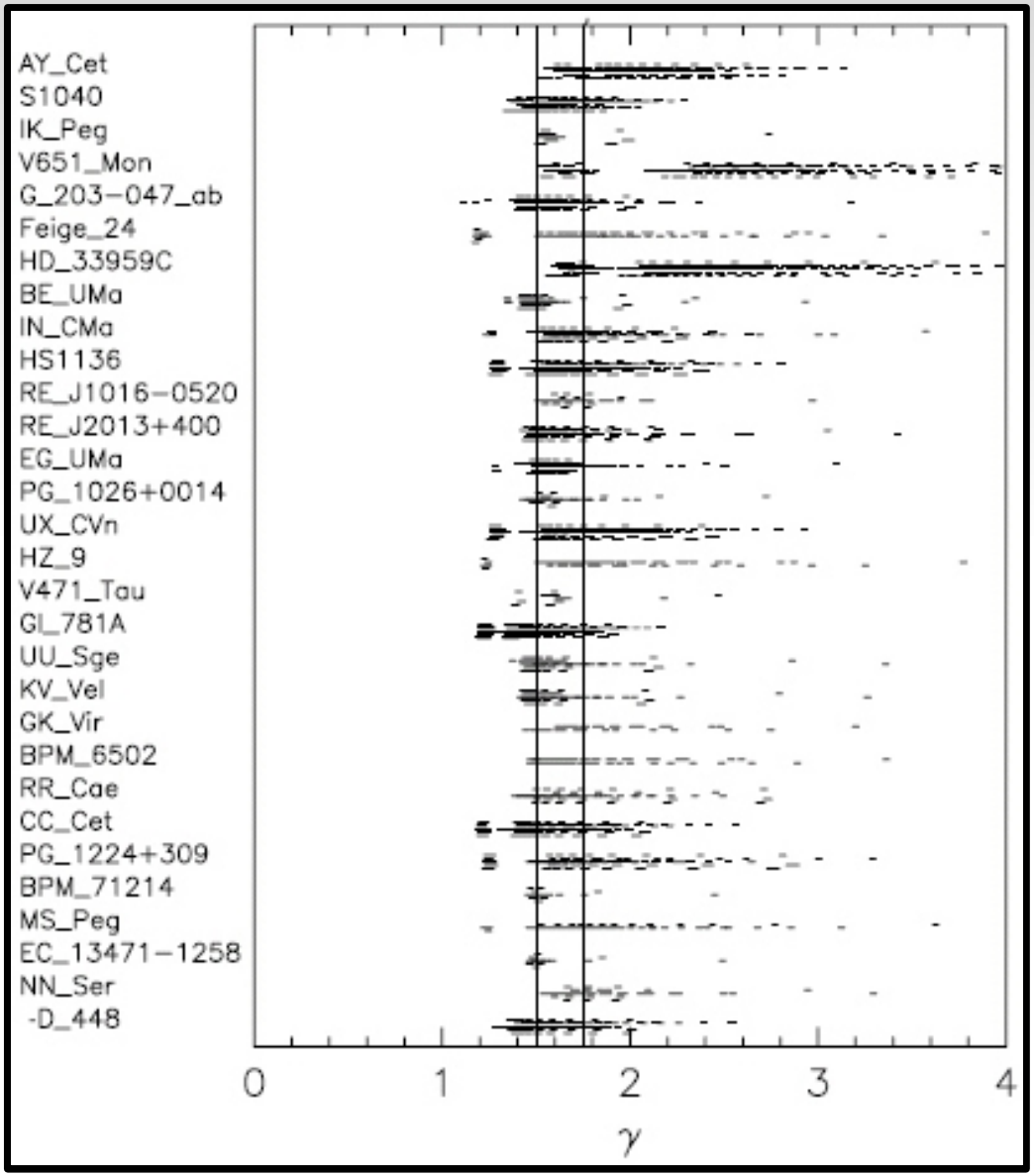
Angular momentum balance

γ-algorithm

$$\frac{\Delta J}{J} = \gamma \frac{\Delta M_{\rm total}}{M_{\rm total}} = \gamma \frac{M_{\rm e}}{M_{\rm g} + m}$$

$1.5 \leq \gamma \leq 1.75$



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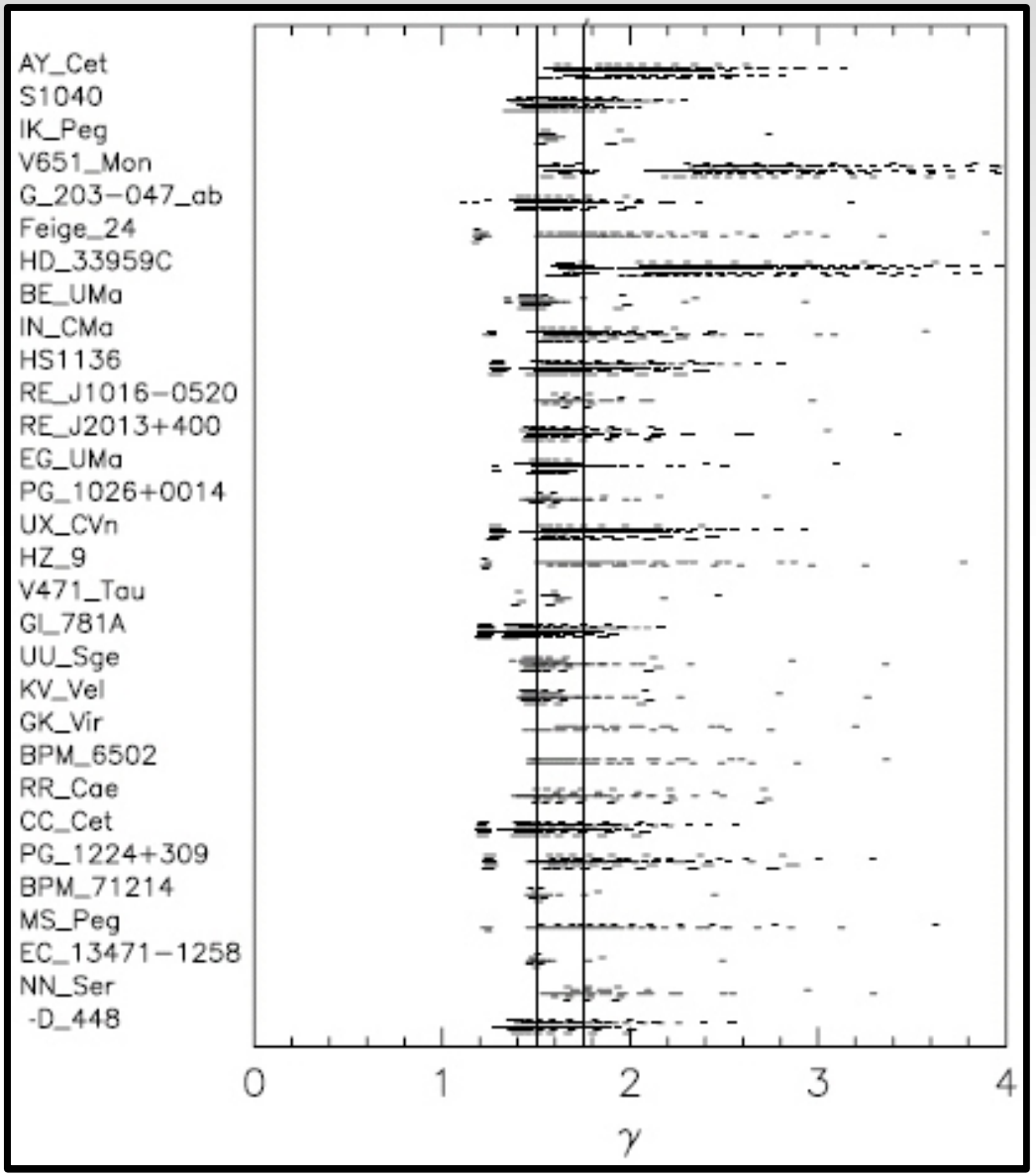
Webbink (2007):
- Not all are PCEBs? Quasi-conservative mass transfer?
- The range of γ is expected.

We need a complete and unbiassed sample of PCEBs

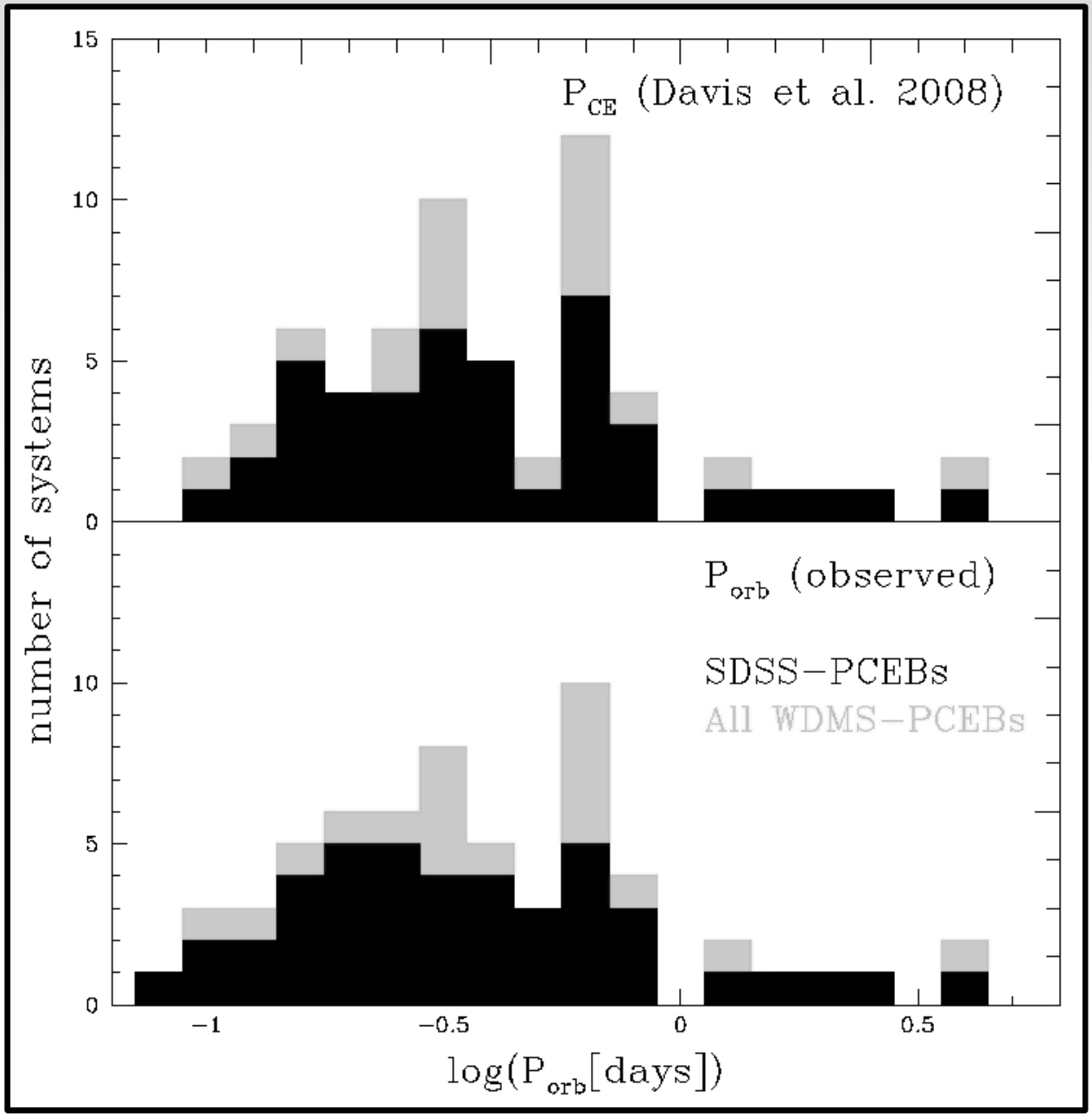


Nelemans & Tout (2005)

The Sample

→ 43 PCEBs from SDSS WD/MS

→ 18 Previously known systems
(N&T2005, S&G2003)



Our Code:
Finding progenitors for the WD

- INPUTS: M_{WD}, m, $P_{CE}(a_f)$
- M_g between 0.8 and M_{max}

- Assuming $M_C = M_{WD}$
  Hurley et al. (2000)
  - L_g using L-M_c-M relations
  - R_g using R-L-M relations

- Assuming $R_g = R_L$
  - $\alpha\lambda$ for every initial mass

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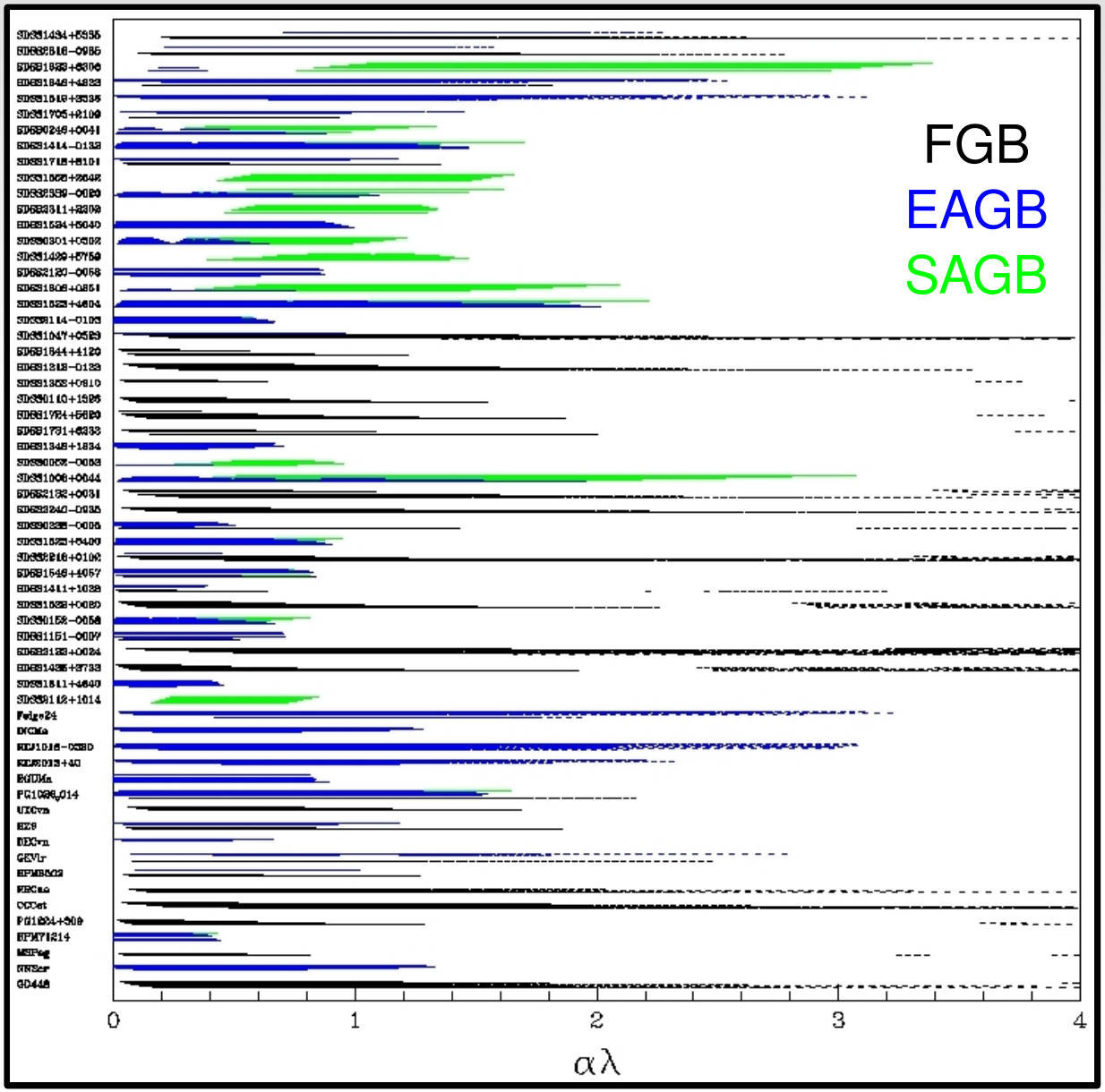


λ and Internal Energy

Structural parameter:

λ depends on evolutionary stage (e.g. Dewi & Tauris 2000)

Internal energy:

Han et al. (1995) include a fraction α_{th} of internal energy

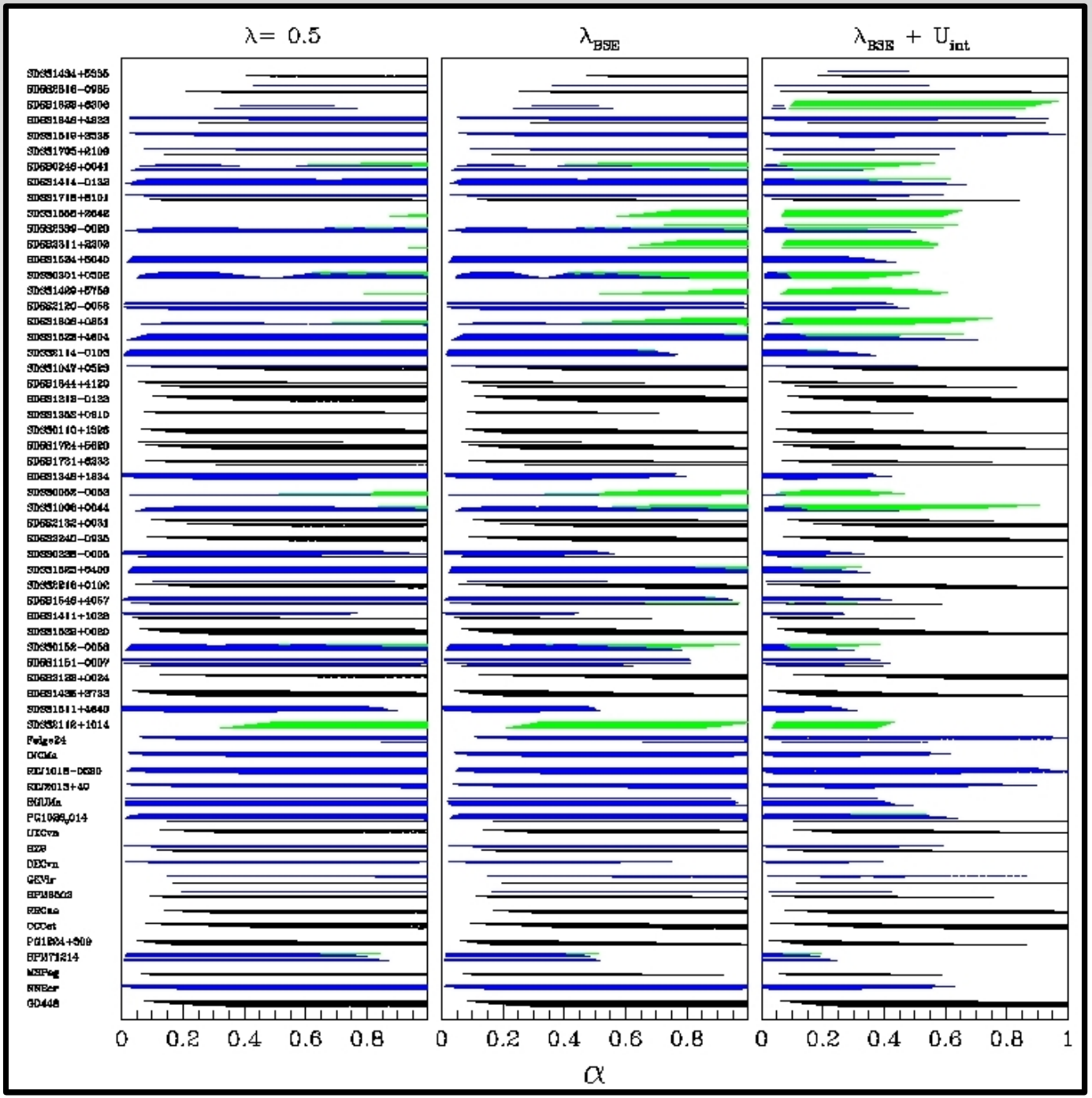
$$\alpha_{\rm CE}\Delta E_{\rm orb} = E_{\rm gr} - \alpha_{\rm th}E_{\rm th}$$

We use BSE code (Hurley et al. 2002) with:

$\alpha_{th} = 0$

$\alpha_{th} = \alpha_{CE}$

λ and Internal Energy

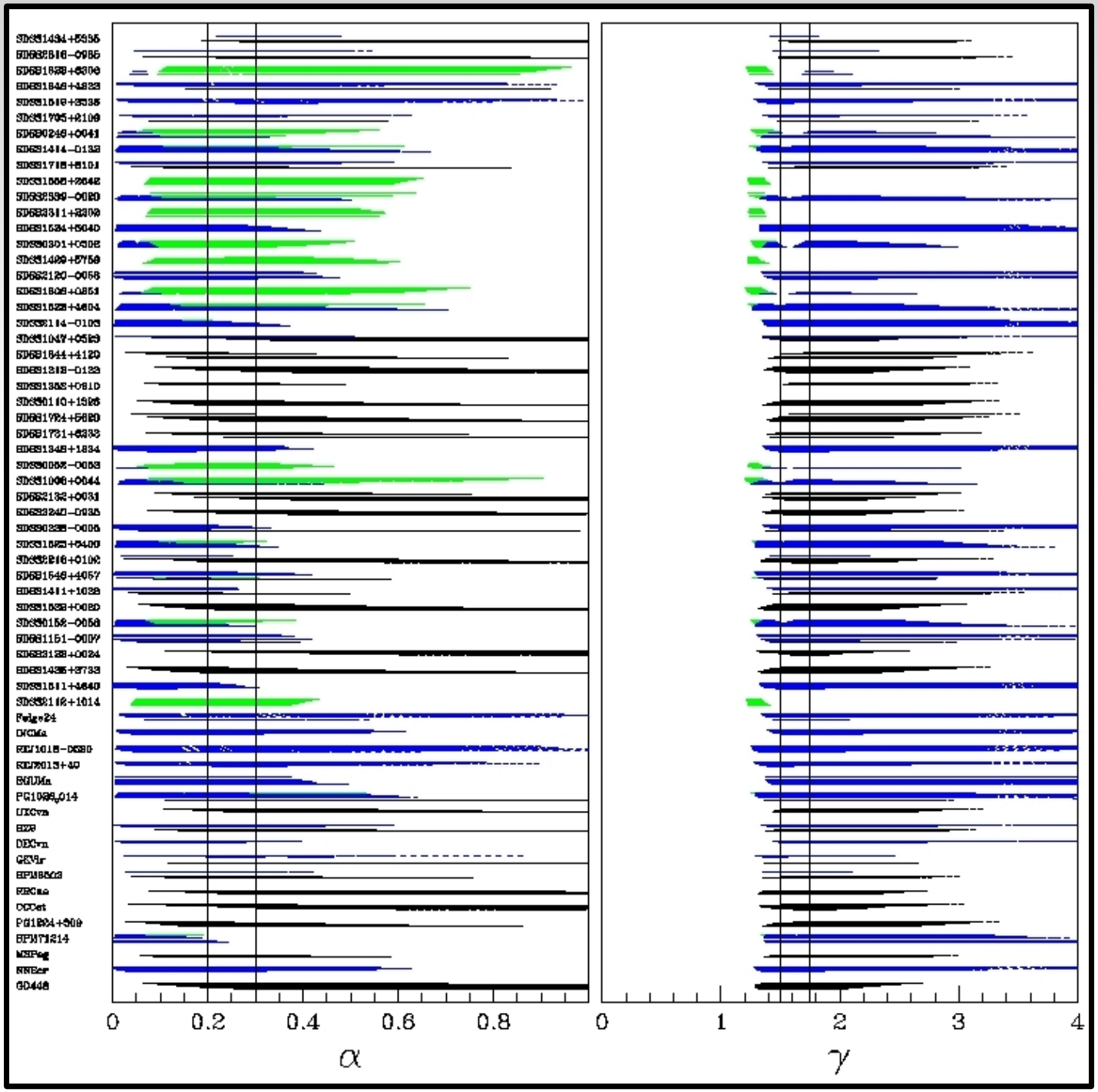


α vs γ

Vertical lines:

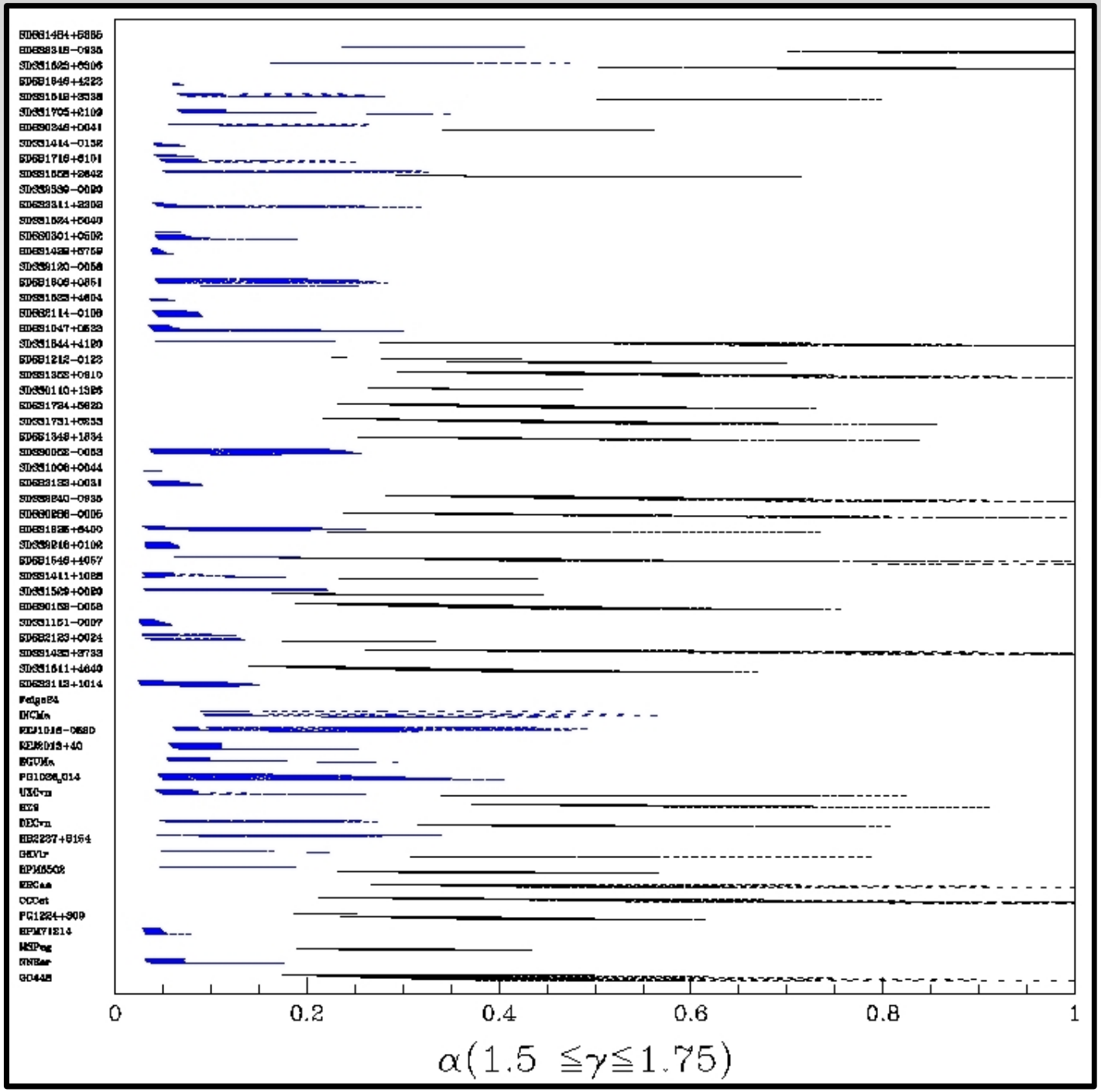
$0.2 \leq \alpha \leq 0.3$

$1.5 \leq \gamma \leq 1.75$



α with γ fixed

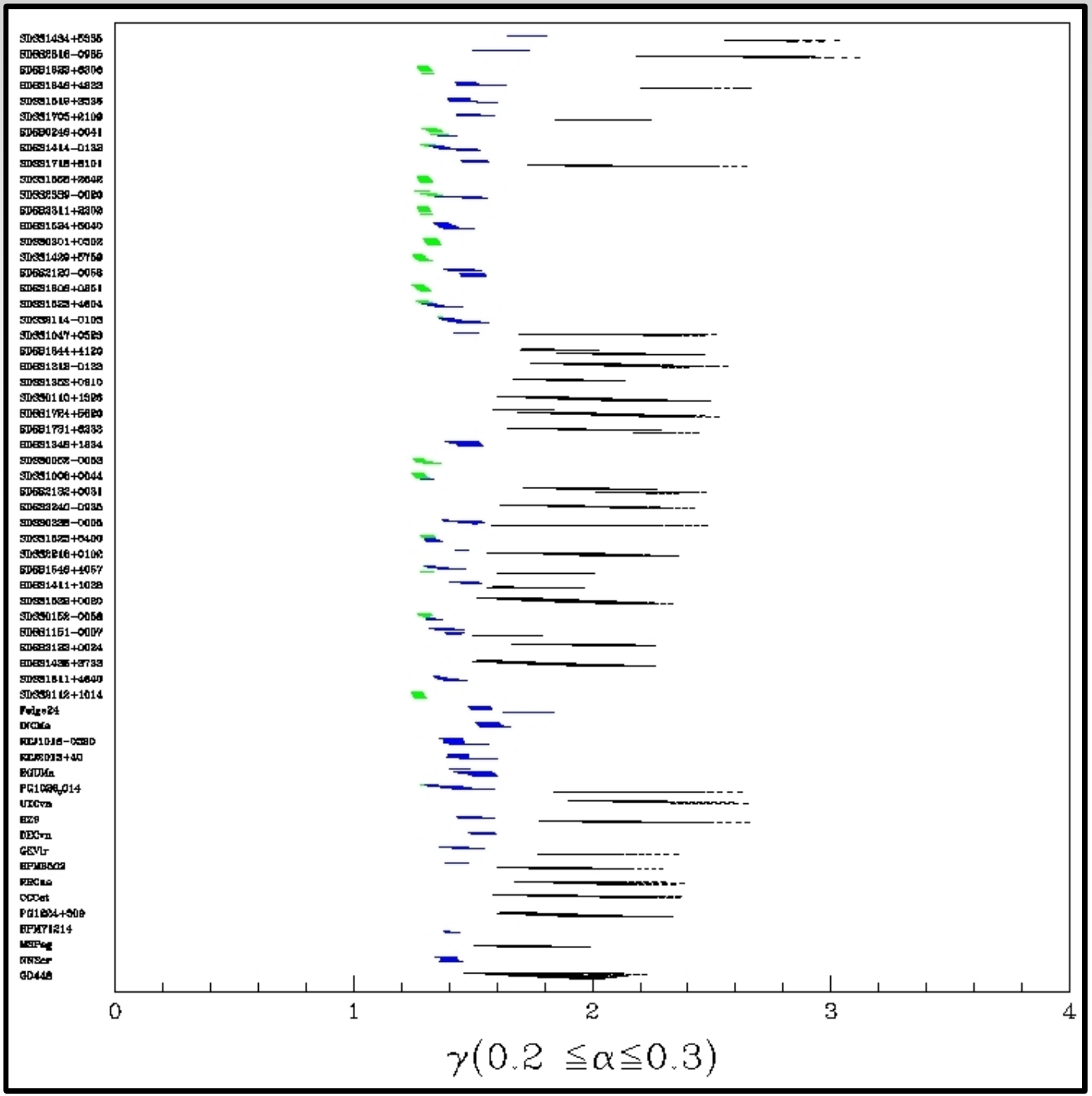
$1.5 \leq \gamma \leq 1.75$



a_f/a_i is extremely sensitive to γ (Webbink 2007)

γ with α fixed

$0.2 \leq \alpha \leq 0.3$



Change in angular momentum per unit mass higher for progenitors in FGB than in AGB

Summary

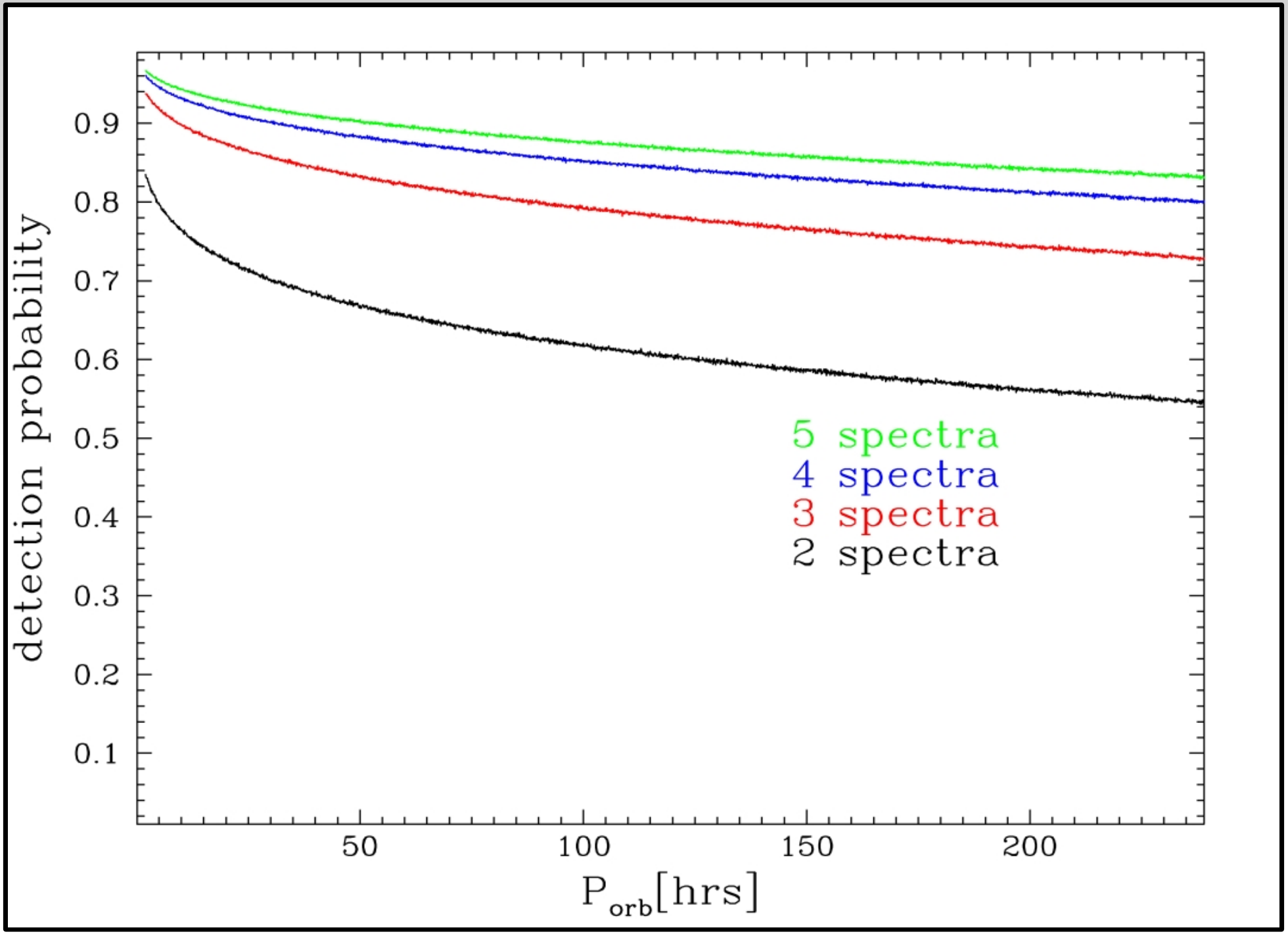
➔ We reconstruct the possible evolutionary histories of a well-defined PCEBs sample including the structural parameter λ and internal energy

➔ Strong new constraints on the CE Efficiency.
If α = constant:

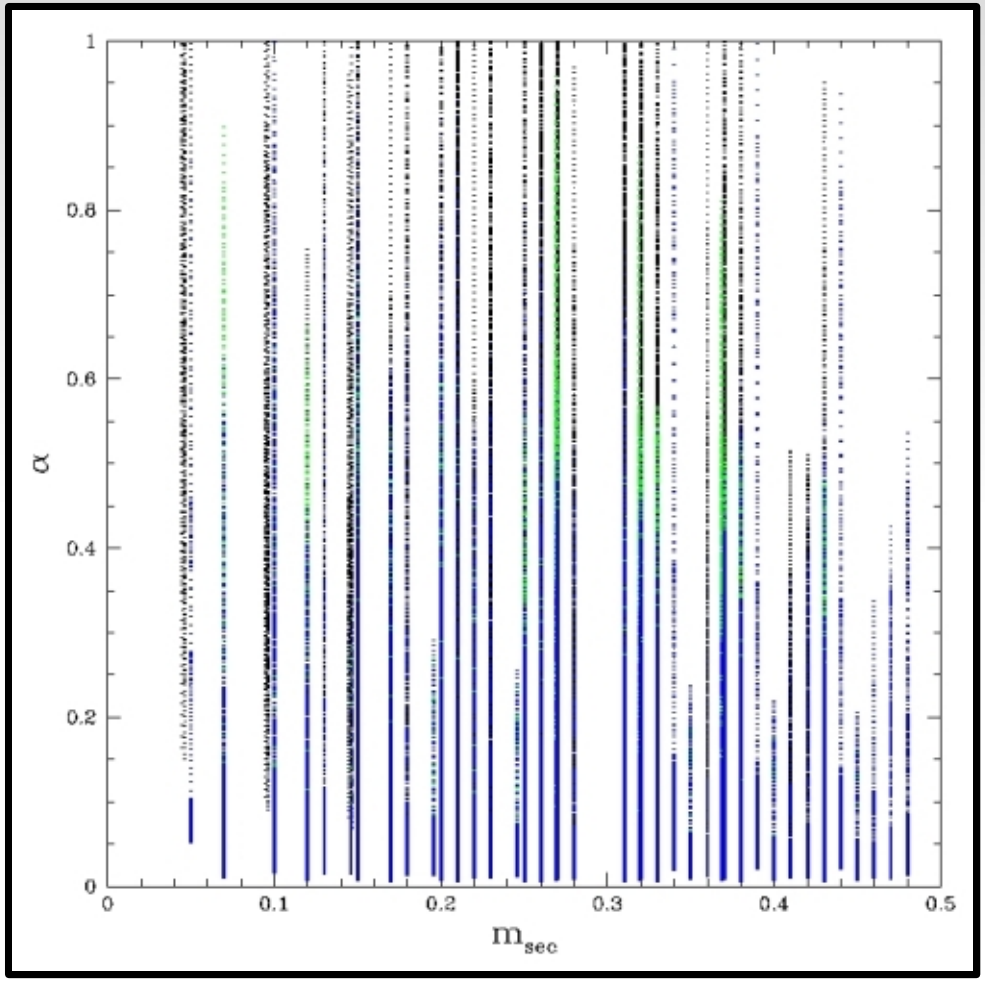
$$\alpha \sim 0.2 - 0.3$$

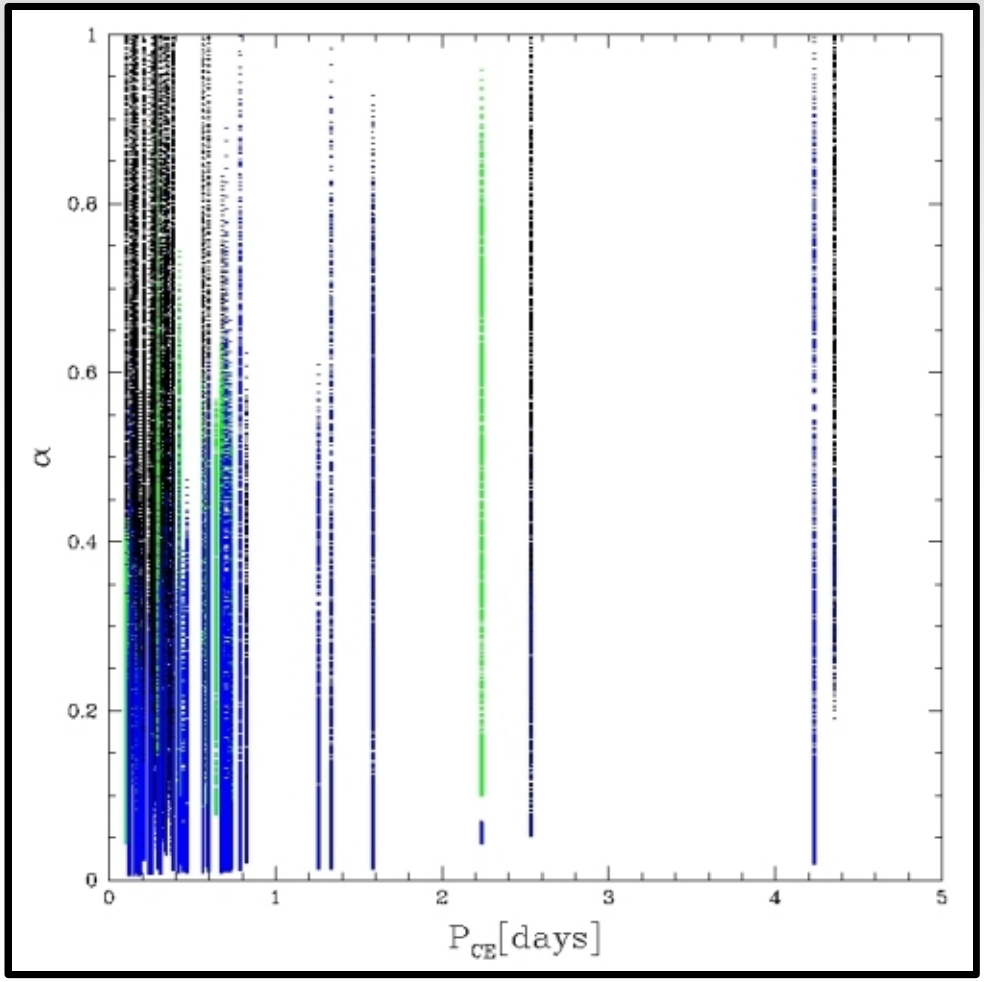
➔ α is better than γ to constrain the evolution of close compact binaries

EXTRAS


detection probability
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
50
100
150
200
P_orb[hrs]
5 spectra
4 spectra
3 spectra
2 spectra

Testing for correlations





Different formulations

- Podsiadlowski et al. (2003)

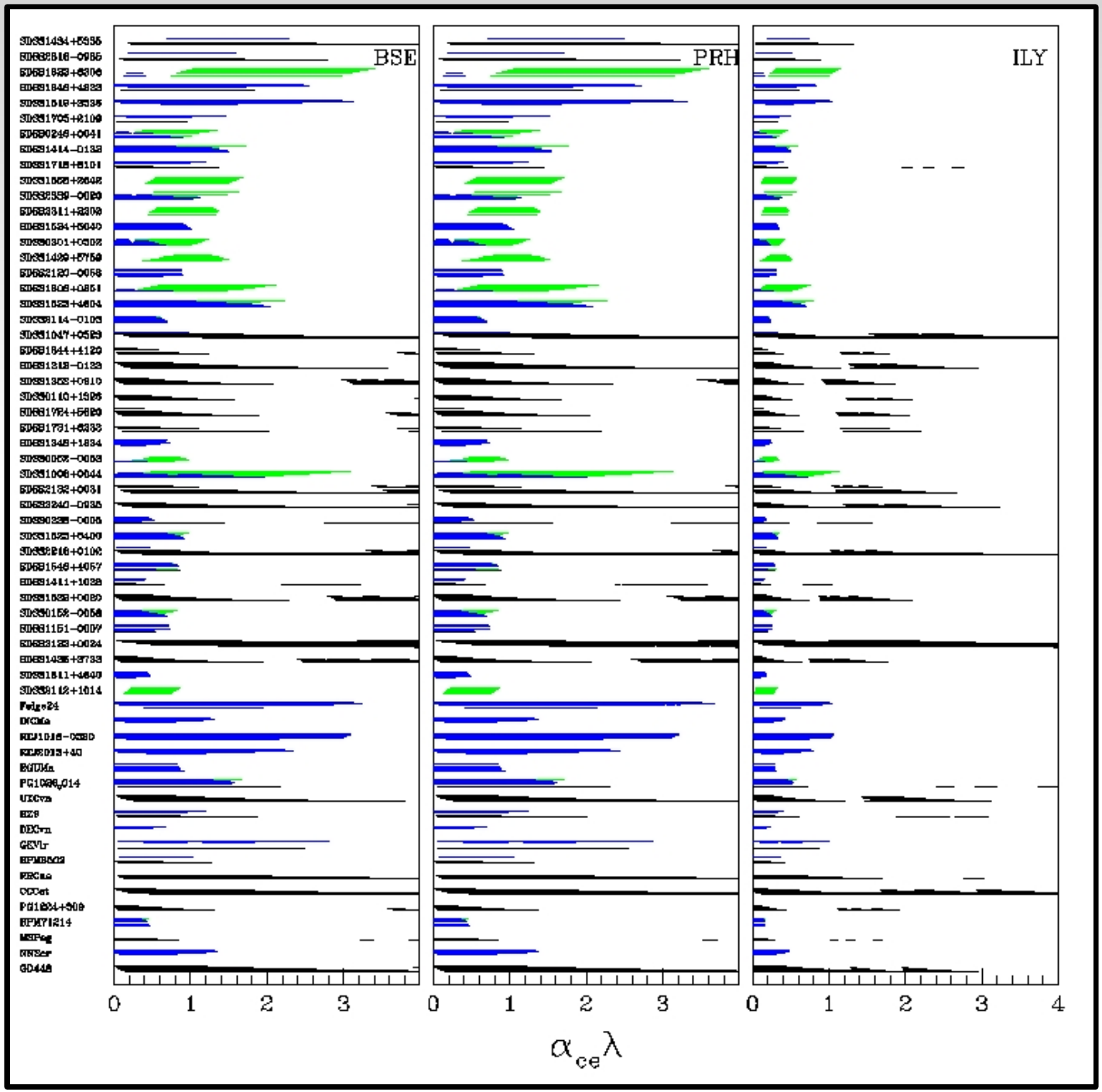
$$E_{\rm orb,i} = \frac{1}{2}\frac{GMm}{a_{\rm i}}$$

$$E_{\rm gr} = \frac{GMM_{\rm e}}{\lambda R}$$

- Iben & livio (1993), Yungelson et al (1994)

$$E_{orb,i} = \frac{1}{2}\frac{GM_{\rm c}m}{a_{\rm i}}$$

$$E_{\rm gr} = \frac{G(M_{\rm g}+m)M_{\rm e}}{2a_{\rm i}}$$



Structural parameter

$$E_{\rm env} = -\frac{GM_{\rm donor}M_{\rm env}}{\lambda a_{\rm i} r_{\rm L}} = \int_{M_{\rm core}}^{M_{\rm donor}} \left(-\frac{GM(r)}{r} + U \right) dm$$