Surface convection
&
Red giants radii measurements

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The data

34 Giants & 4 subgiants

CHARM2 *(Richichi et al. 2005)*
Wittkowski et al. (2006)
CHARA/FLUOR

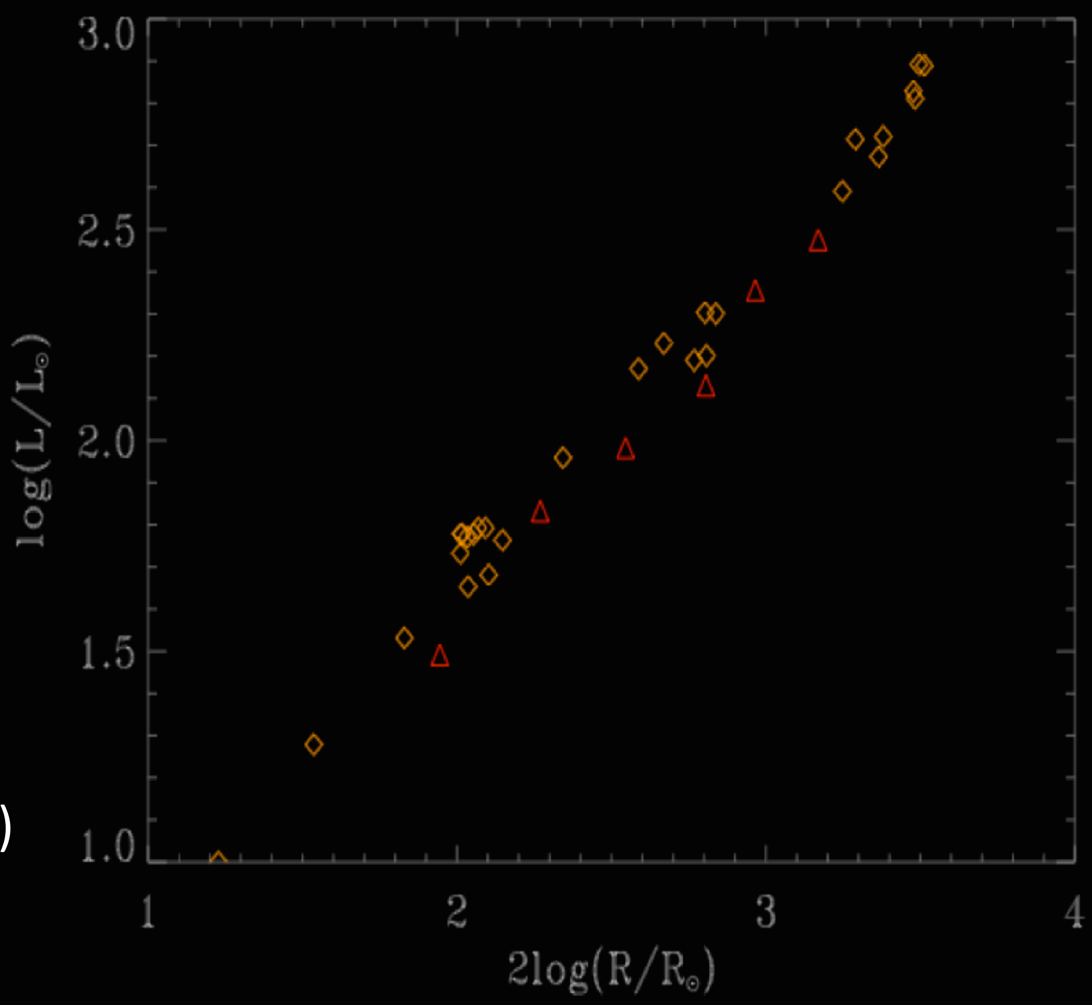
$2\ R_\odot \leq R \leq 60\ R_\odot$

Nearby : d < 110 pc

Population I : [Fe/H] ≈ -0.17

$3\ L_\odot \leq L \leq 800\ L_\odot$

3805 K (M0) $\leq T_{eff} \leq$ 5520 K (G5)



The stellar structure code : CESAM

Stellar evolution from ZAMS to $10^3\ L_\odot$: $0.9\ M_\odot$ to $2.5\ M_\odot$

The radius is sensitive to :

The opacities OPAL & Ferguson (2004) ; composition Asplund et al. (2005)

The atmosphere boundary conditions

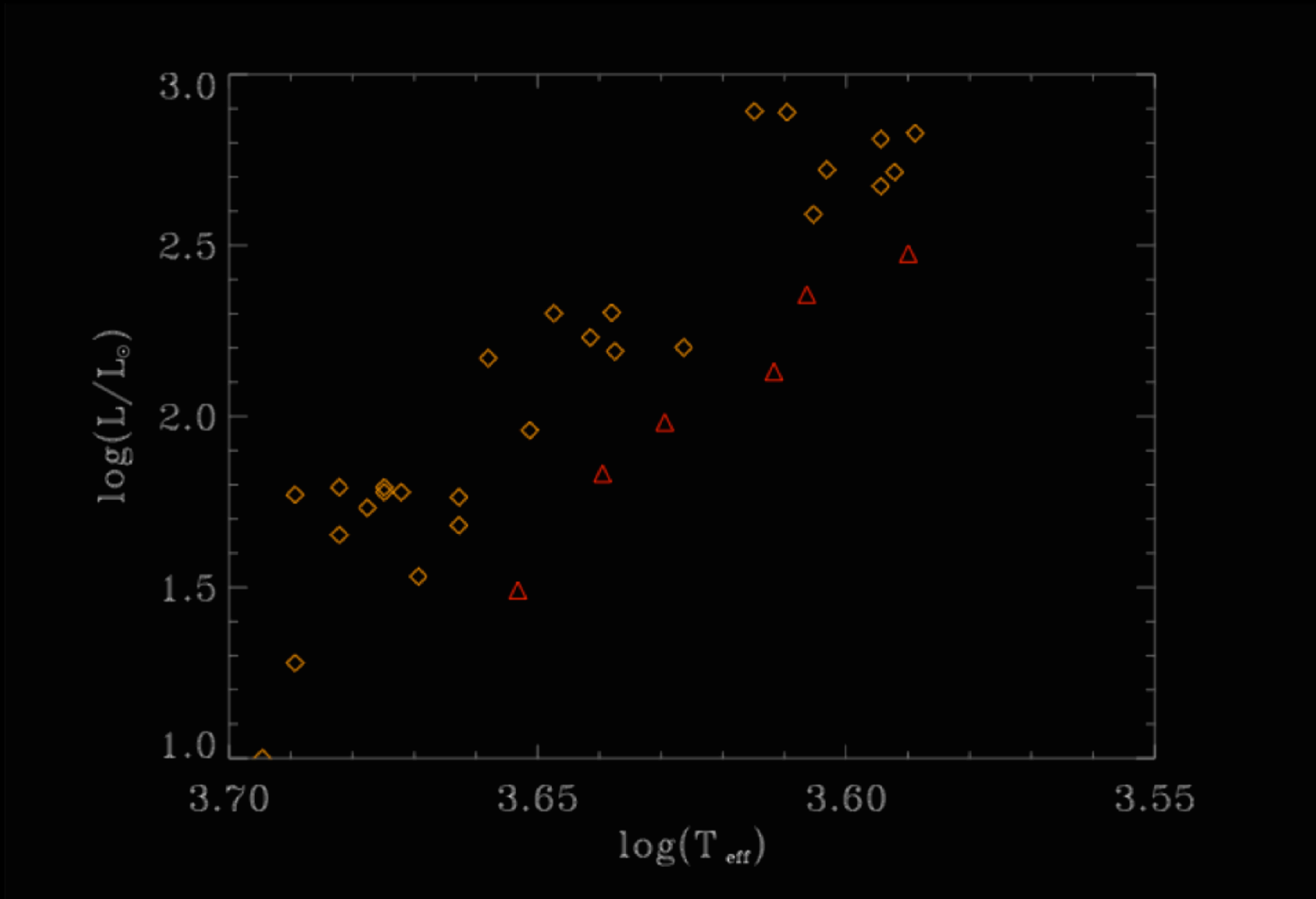
Two grids of non grey $T(\tau)$ relations in Teff and log g

- Phoenix 1D models $\alpha_{mlt}=2$
- Atlas12 models $\alpha_{cgm}=0.5$

The surface convection : $\Lambda=\alpha H_p$

- Mixing length theory : $\alpha_{mlt}=1.58$ (Boehm-Vitense 1958)
- Full spectrum of turbulence : $\alpha_{cgm}=0.77$ (Canuto, Goldman & Mazzitelli 1996)

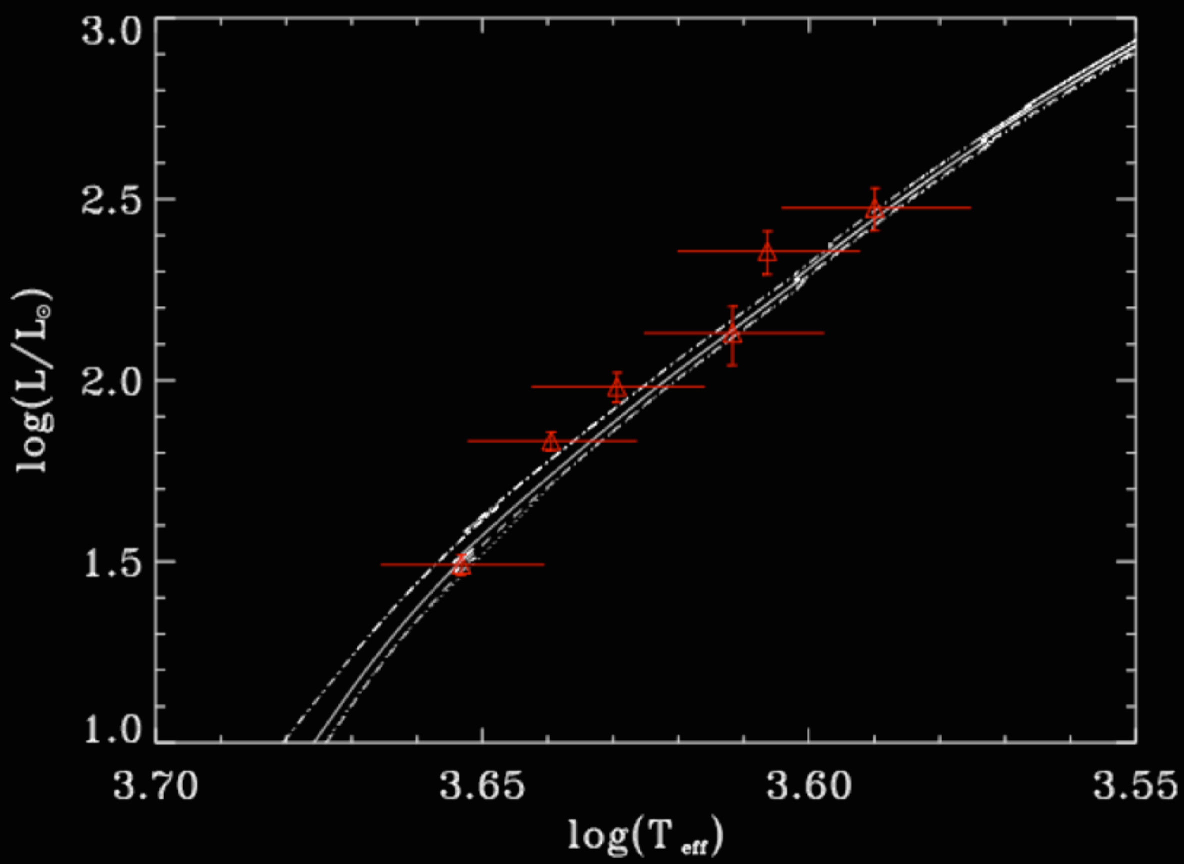
The cool edge of the RGB



The age of the RGB is constrained by

Local disk age ≤ 11.7±1.9 Gyr *Liu & Chaboyer (2000)*
Globular clusters age ≤ 12.6 Gyr *Krauss & Chaboyer (2003)*

The MLT and the HR diagram



1) Solid line :
0.95 $M_\odot$, 11.6 Gyr, [Fe/H] = -0.17
α_{mlt} =1.58

$$\chi_1^2 = \Sigma_{i=1}^{N} \frac{1}{N} [\frac{T_{mod} - T_{obs}}{\Delta T_{obs}}]^2$$

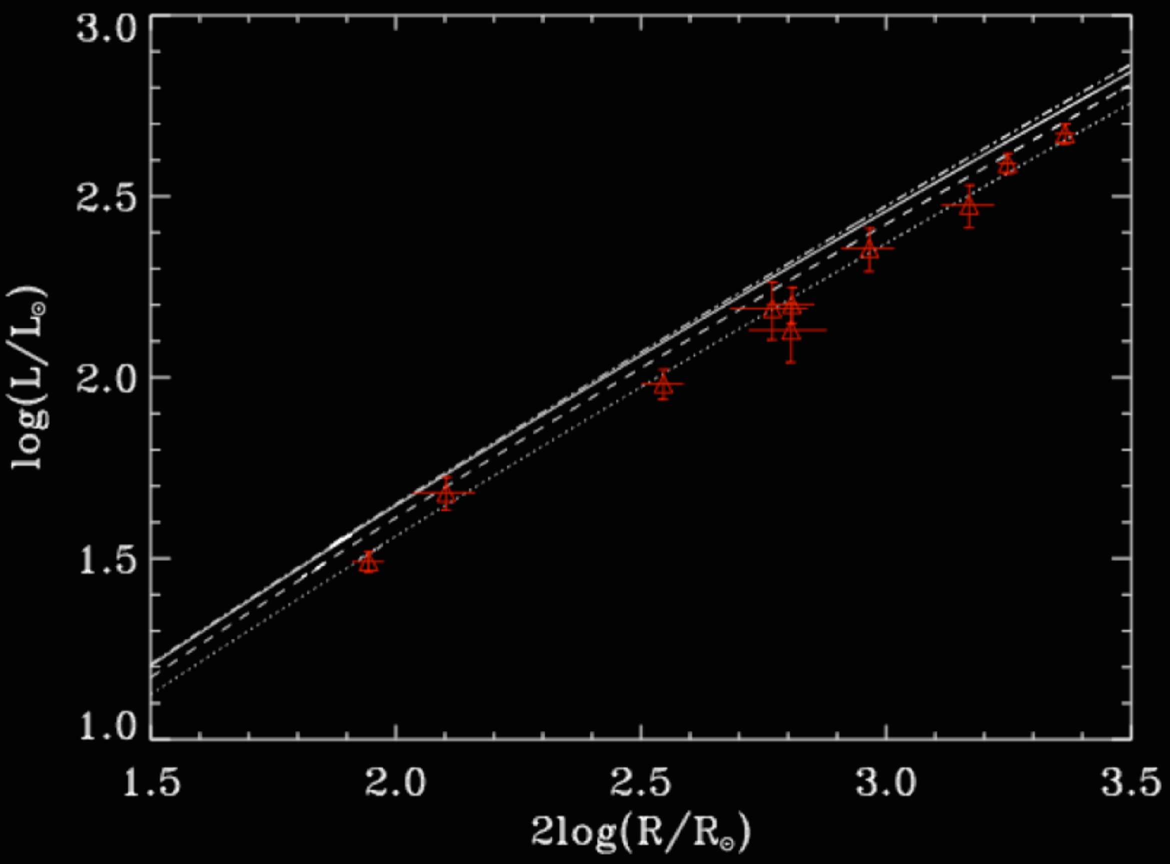
χ_1^2=0.15 χ_2^2=0.45 (3.6)

2) Dotted line : χ_1^2=0.23
X_2^2=0.40 (4.2)
0.92 $M_\odot$ and 13.0 Gyr

3) Dot-dashed line :
χ_1^2=0.11 χ_2^2=0.61 (3.1)
1.25 $M_\odot$ and [Fe/H] =0

T_{eff} & R constraints : no change of α_{mlt} from the Sun to the RGB

The CGM theory and the L vs. R^2 diagram



1) Solid line :
0.95 $M_\odot$, 11.6 Gyr, [Fe/H]= -0.17
α_{cgm} =0.77

$$\chi_2^2 = \Sigma_{i=1}^{N} \frac{1}{N} [\frac{R^2_{mod} - R^2_{obs}}{\Delta R^2_{obs}}]^2$$

$\chi_2{}^2$=7.1 $\chi_2{}^2$=6.3

2) Dashed line :
0.98 $M_\odot$, 12.5 Gyr, [Fe/H] =0
$\chi_2{}^2$=2.7 $\chi_2{}^2$=3.4

3) Dotted line :
0.95 $M_\odot$, 11.8 Gyr
α_{cgm} =0.62
$\chi_2{}^2$=0.9 $\chi_2{}^2$=0.6

T_{eff} & R constraints : slight drop of α_{cgm} from the Sun to the RGB

The cool edge of the RGB : summary

Mass ($M_\odot$)	**Convection**	**χ^2HR**	**χ^2LR^2**	**Remark**
0.95	**α_{mlt}=1.58**	0.15	0.45	Good fit
0.95	**α_{cgm}=0.62**	0.11	0.89	Good fit
0.95	**α_{cgm}=0.77**	5.1	7.1	Poor fit
0.92	**α_{mlt}=1.58**	0.23	4.2	Too old
1.25	**α_{mlt}=1.58**	0.11	3.1	Too high [Fe/H]

Mass repartition

Assumption

The mass distribution on the RGB is the present day mass function

(No mass loss & sample identical to field stars)

$$\frac{dN}{dM} \propto M^{-2.3\, to\, -2.7}$$

Kroupa (2002)

Method

Models from ZAMS to 10^3 $L_\odot$:

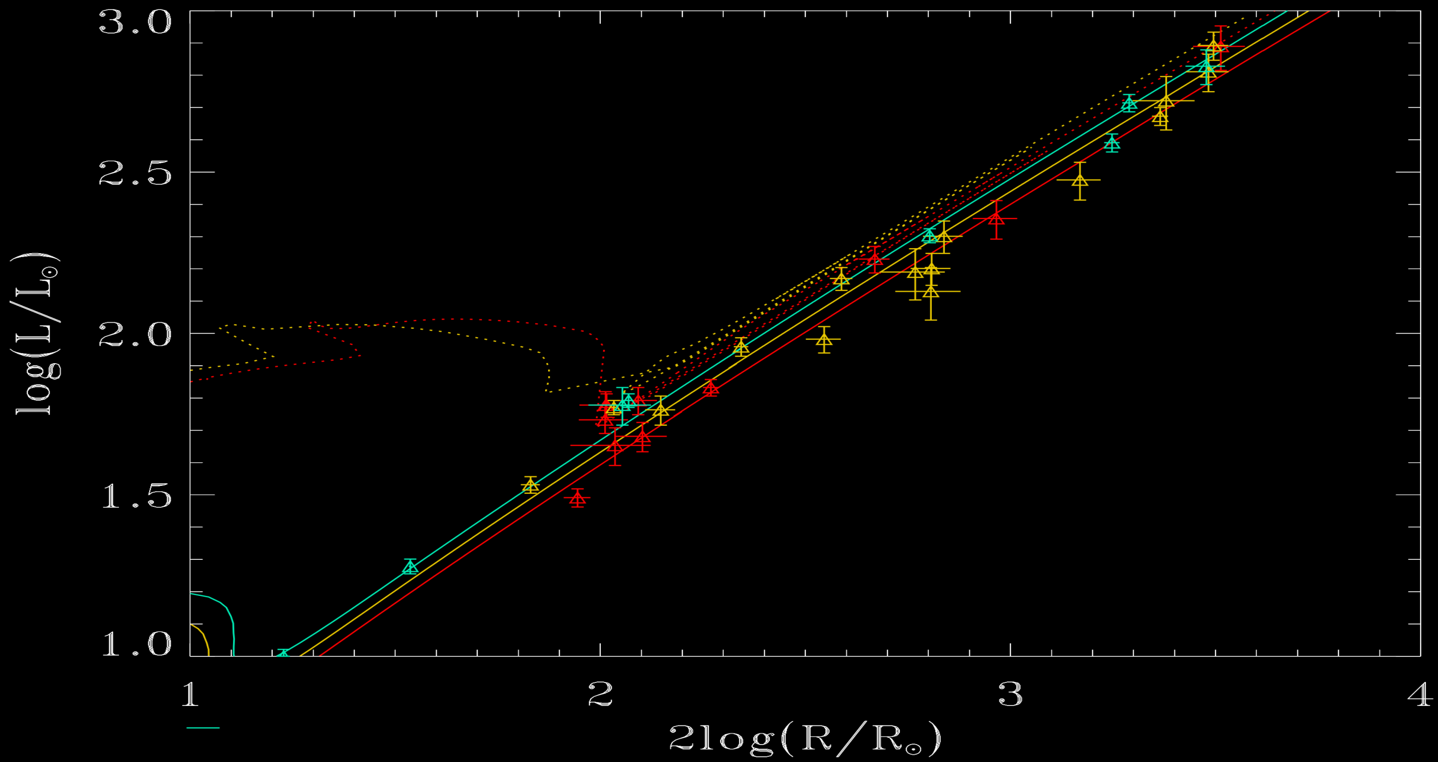
For : 1.5 $M_\odot$ and 2.5 $M_\odot$

For : [Fe/H] = 0, -0.17 and -0.34

For : α_{cgm} =0.77 and α_{cgm} =0.62

We compare the data distribution between tracks and the expected mass distribution on the RGB

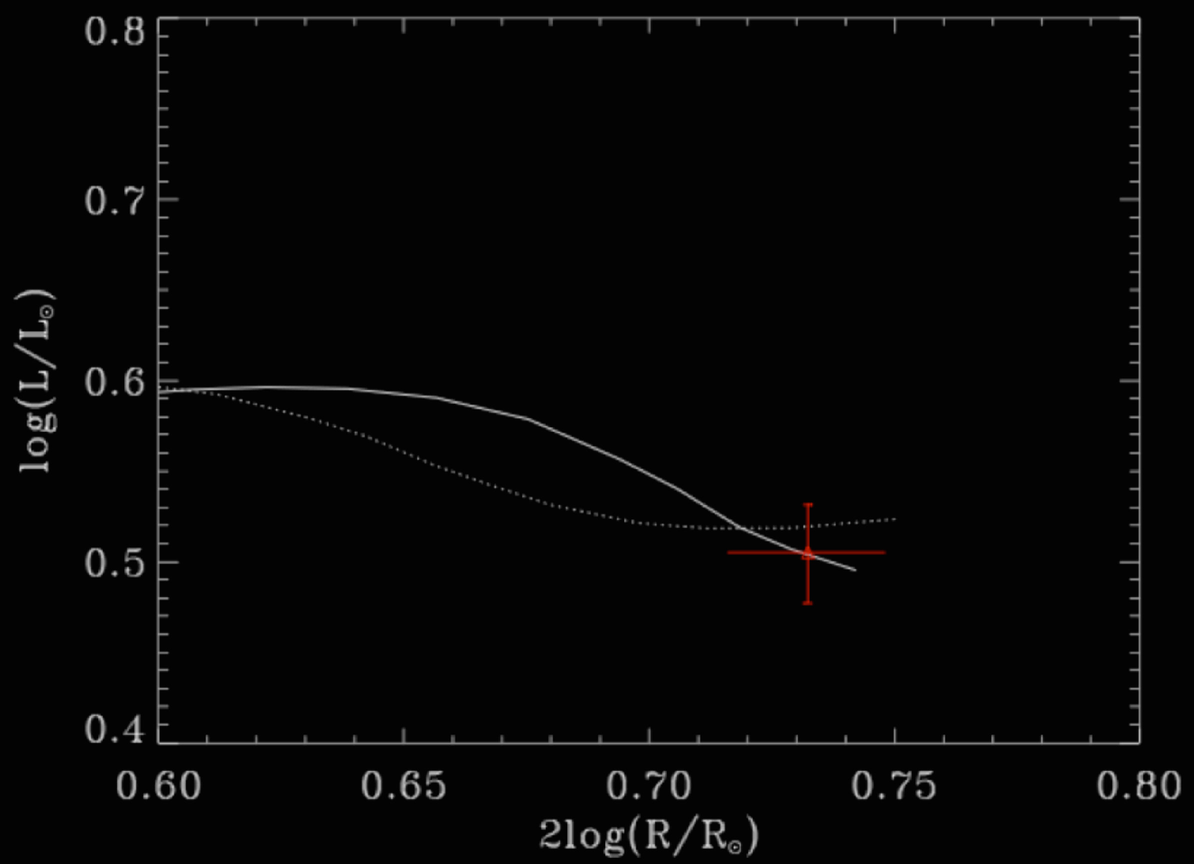
α_{cgm}=0.62



Mass range	PDMF %	α_{cgm}=0.77	α_{cgm}=0.62
< 1.5M⊙	54	84 ± 15	48 ± 11
1.5 to 2.5 M⊙	27	16 ± 7	40 ± 10
> 2.5M⊙	19	0	11 ± 5

Seismic constraints

δEri : 1.22 ±0.05 $M_\odot$, [Fe/H] =0.13 (!), α_{ov}=0.1
εOph: 1.85 ±0.05 $M_\odot$, [Fe/H] = -0.27 , α_{ov}=0.2
ξHya : 2.65±0.05 $M_\odot$, [Fe/H] = -0.04 , α_{ov}=0.2



Solid : α_{cgm} =0.62

Dotted : α_{cgm} =0.77

Very sensitive and supporting a lower convection length scale

Seismic constraints

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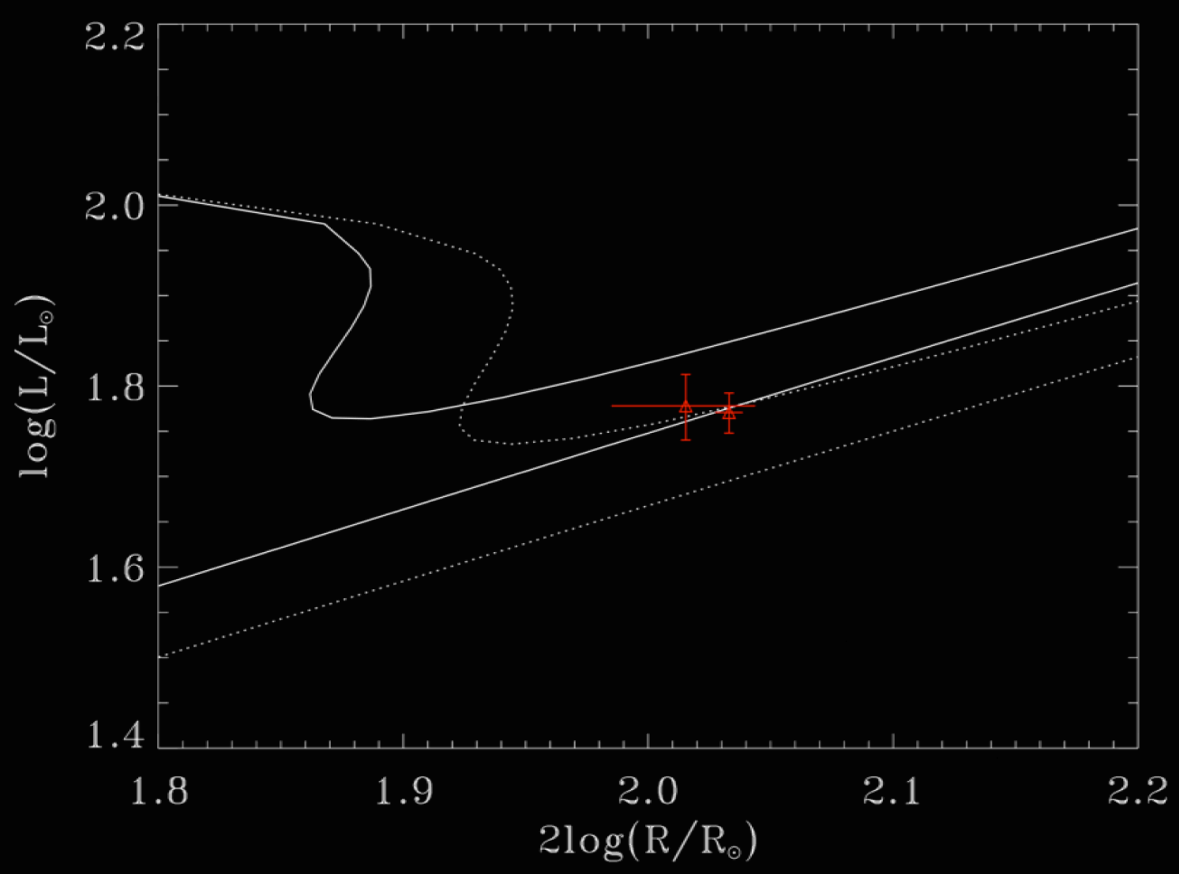

Solid : α_{cgm} =0.62

Dotted : α_{cgm} =0.77

Conclusions (I)

No need for change of MLT length scale

Slight drop of the CGM theory length scale

Results consistent in HR and LR^2 diagrams

Results on the cool edge/large radii consistent with mass distribution(?)

Piau et al. (2010), in prep

Conclusions (II)

Future :

Larger sample would enable tests based on mass repartition

Test very sensitive to radius and seismic constraints (Kepler, CoRoT)

Tests of other prescriptions of convection and 3D convection