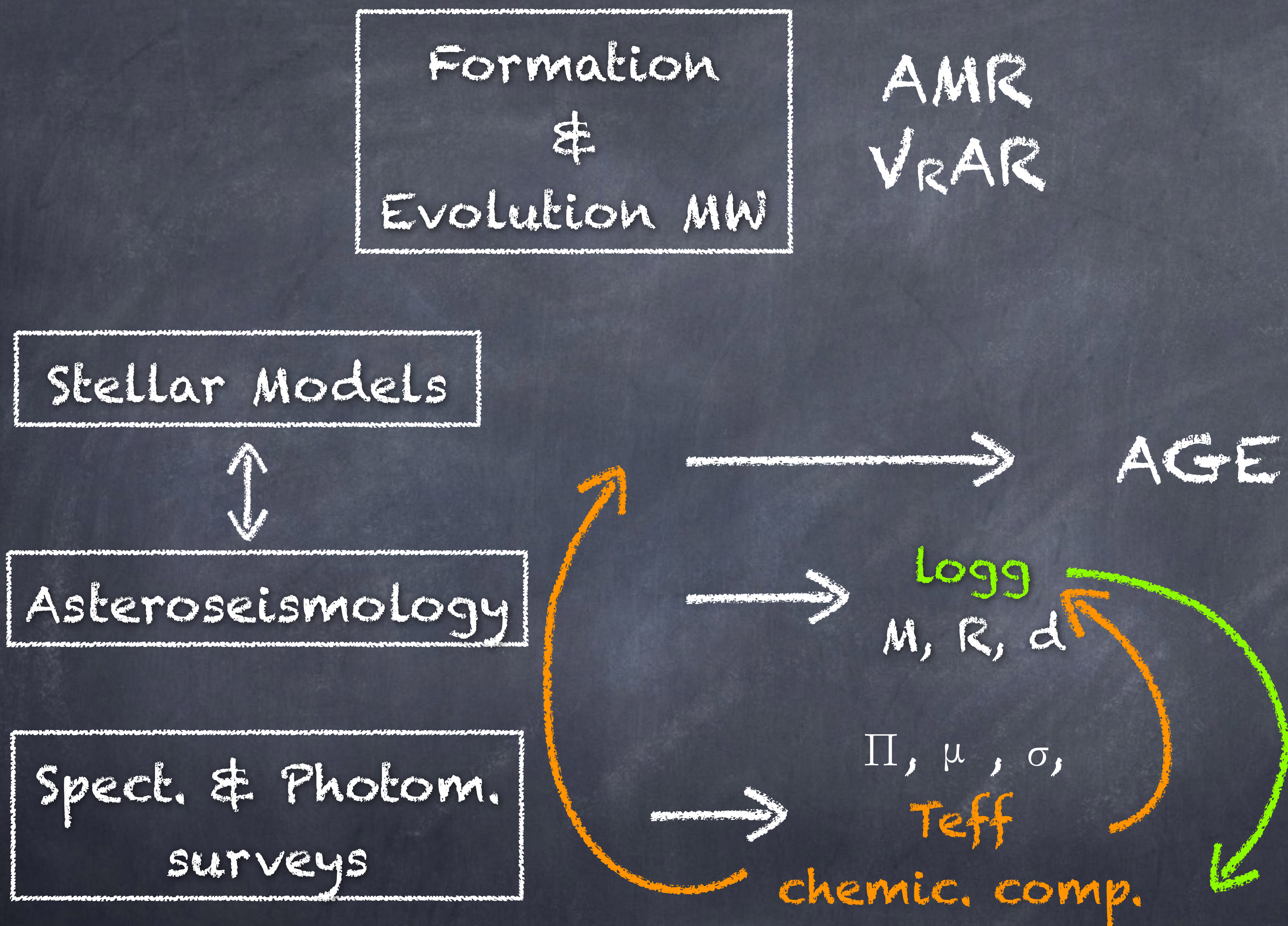

Where are we now and where are we going?
Arlette Noels & Josefina Montalbán



Formation & Evolution MW
AMR
V_RAR
Stellar Models
Asteroseismology
Spect. & Photom. surveys
AGE
logg
M, R, d
Π, μ , σ,
Teff
chemic. comp.

Letter

Nature **459**, 398-400 (21 May 2009) | doi:10.1038/nature08022; Recei
26 March 2009

Non-radial oscillation modes with long lifetimes in giant stars

Joris De Ridder[1], Caroline Barban[2], Frédéric Baudin[3], Fabien Carrier[1], Artie P. Hatzes[4], Saskia Hekker[5,1], Thomas Kallinger[6], Werner W. Weiss[6], Annie Baglin[2], Michel Auvergne[2], Réza Samadi[2], Pierre Barge[7] & Magali Deleuil[7]

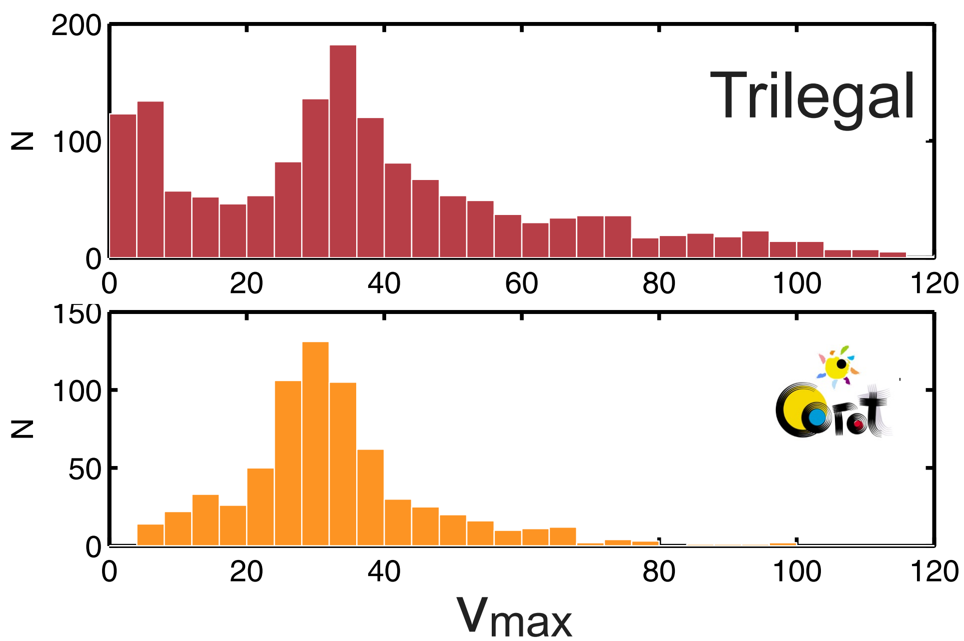
huge number of giants

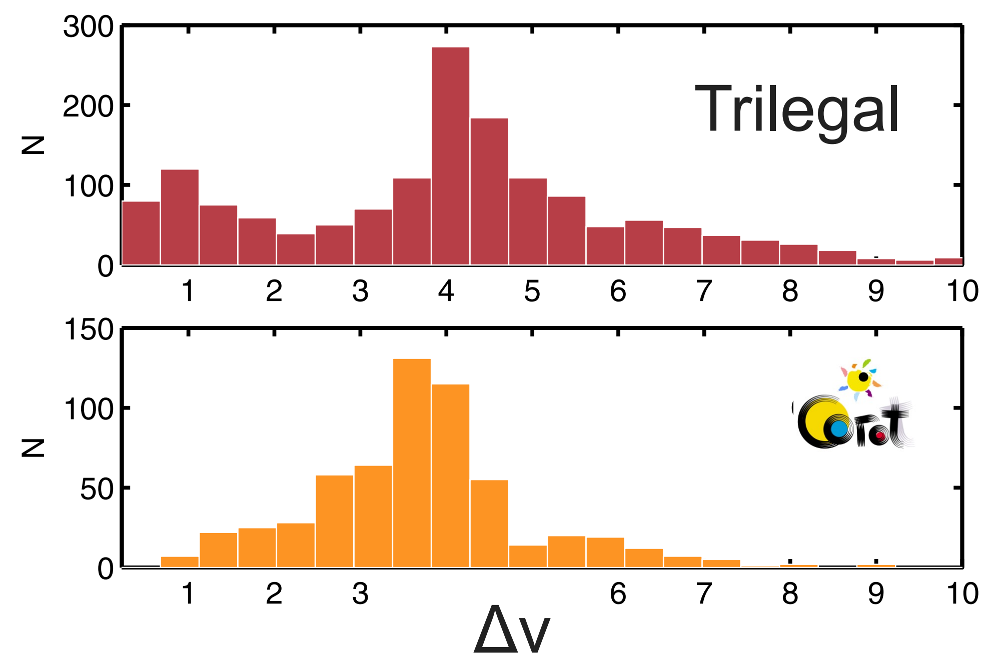
Probing populations of red giants in the galactic disk with CoRoT*

A. Miglio[1,**], J. Montalbán[1], F. Baudin[2], P. Eggenberger[1,3], A. Noels[1], S. Hekker[4,5,6], J. De Ridder[5],
W. Weiss[7], and A. Baglin[8]

26 July 2009

Comparison CoRoT/Trilegal





Red Giants as probes of the structure and evolution of the MW

(A.Miglio J. Montalban, A. Noels)

Rome, Nov. 2010

Stellar ev. models

A. Weiss
M. Salaris
P. Eggenberger
S. Cassisi
C. Charbonnel
A. Palacios

Atm. & chemic. abund.

H. Ludwig
B. Plez
M. Valentini
R. Gratton

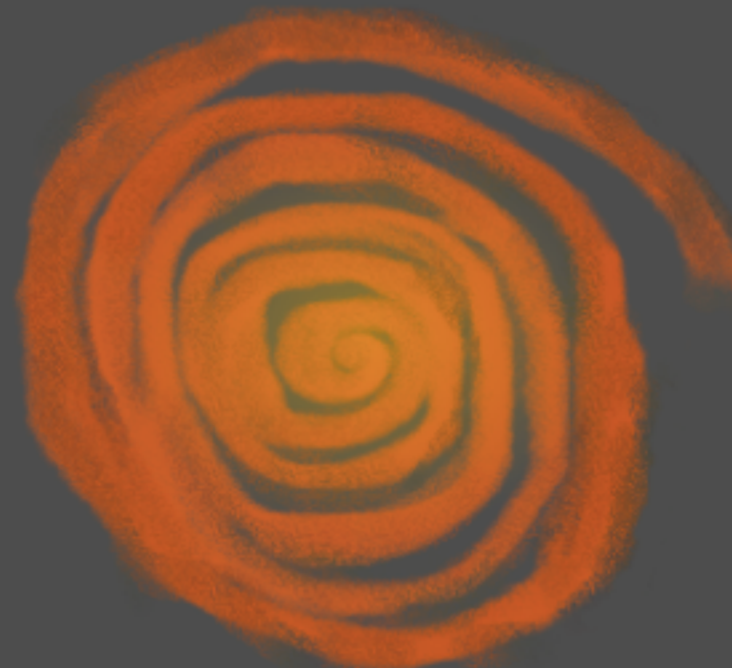
Stellar Pop. & Models of MW

L. Girardi
K. Freeman
C. Chiappini
A. Robin

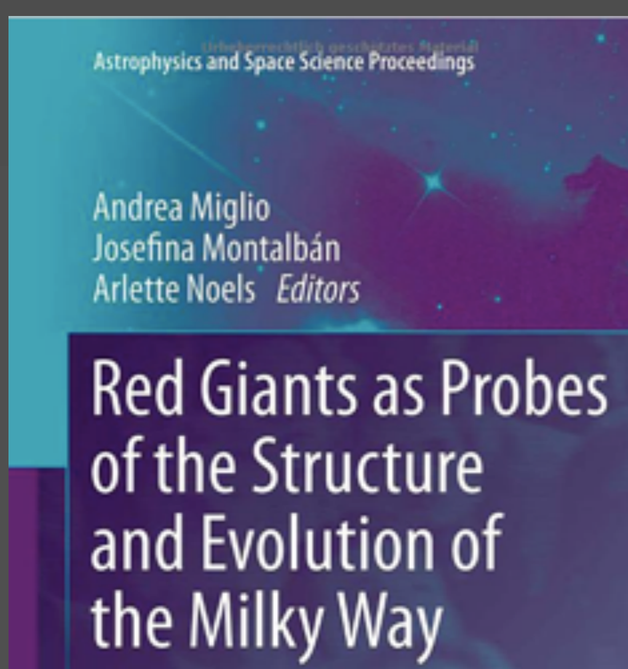
Seismology

W. Dziembowski
B. Mosser

RED GIANTS AS PROBES OF THE STRUCTURE AND EVOLUTION OF THE MILKY WAY



Academia Belgica
Roma
15-17 November 2010



35 participants

Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY

MNRAS **429,** 423–428 (2013) doi:10.1093/mnras/sts345

Galactic archaeology: mapping and dating stellar populations with asteroseismology of red-giant stars

A. Miglio,[1,2★] C. Chiappini,[3] T. Morel,[4] M. Barbieri,[5] W. J. Chaplin,[1] L. Girardi,[6] J. Montalbán,[4] M. Valentini,[4] B. Mosser,[7] F. Baudin,[8] L. Casagrande,[9] L. Fossati,[10] V. Silva Aguirre[11] and A. Baglin[7]

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Geneva Observatory, University of Geneva

Josefina Montalban

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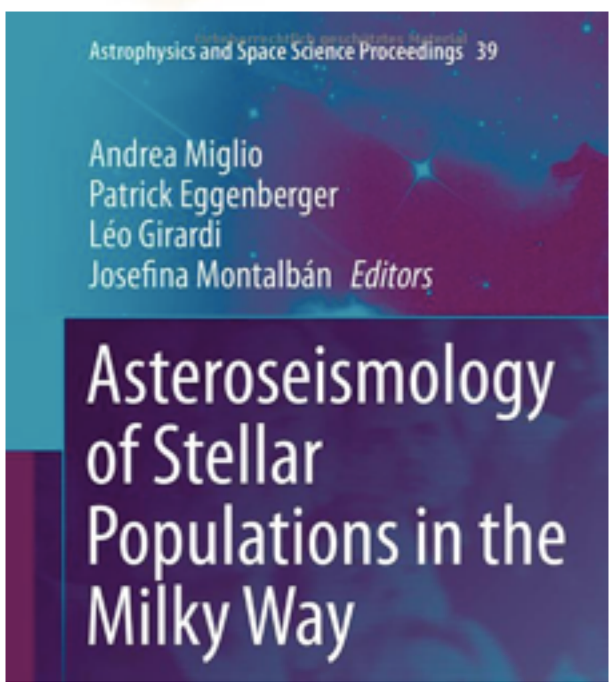
Asteroseismology of stellar populations in the Milky Way

22.07.2013 - 26.07.2013

Haus Sexten - Via Dolomiti 45, 39030, Sexten



40 participants

592. WE-Heraeus-Seminar – 1st to 5th June 2015

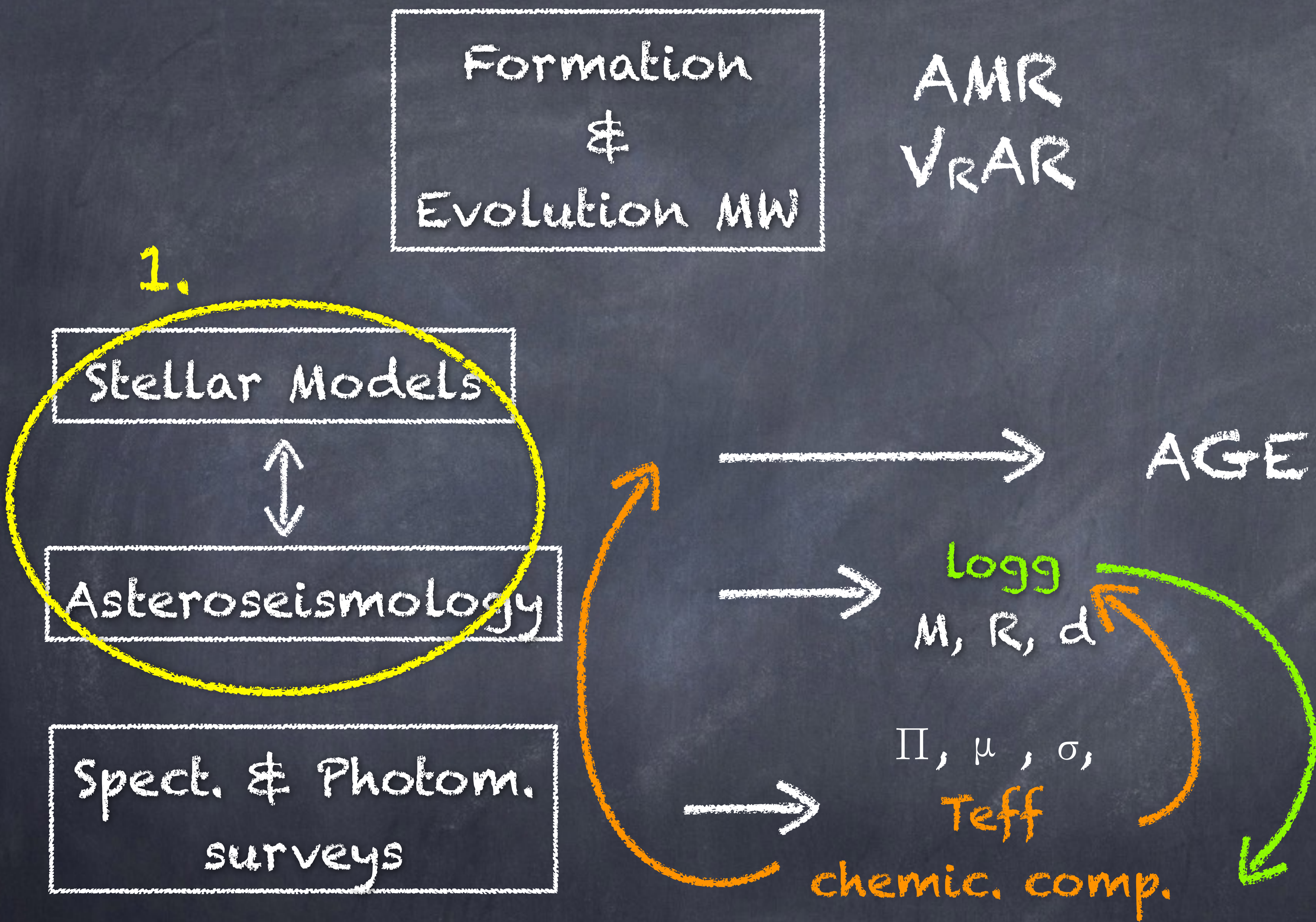
Reconstructing the Milky Way's History: Spectroscopic Surveys, Asteroseismology and Chemodynamical Models

Venue:

Physikzentrum Bad Honnef
Hauptstraße 5
53604 Bad Honnef (near Bonn, Germany)

Astronomical Notes
Astronomische Nachrichten
Founded by H.C. Schumacher in 1821

70 participants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1. Stellar models and asteroseismology

Grids of stellar models

Dwarfs

Pisa stellar models - X, Z, M, Te, L, $\Delta\nu$, ν_{max}

M ⇒ ± 4.5 %

R ⇒ ± 2.2 %

Age ⇒ -35 +42 %

Fe/H ⇒ 40 % of the error budget

Extreme grids

- $\Delta Y/\Delta Z$ ⇒ negligible effect on age
- l_{MLT} (1.50-1.98) ⇒ Age bias 20-30 %
- Diffusion ⇒ Age bias 40 %
- α_{e-m} ⇒ Age bias - 7 % (α=0.2)

  - 13 % (α=0.4)

But … internal errors

Garstec grids - X, Z, M, Te, L, $\Delta\nu$, ν_{max} , ν

M ⇒ ± 5.5 %

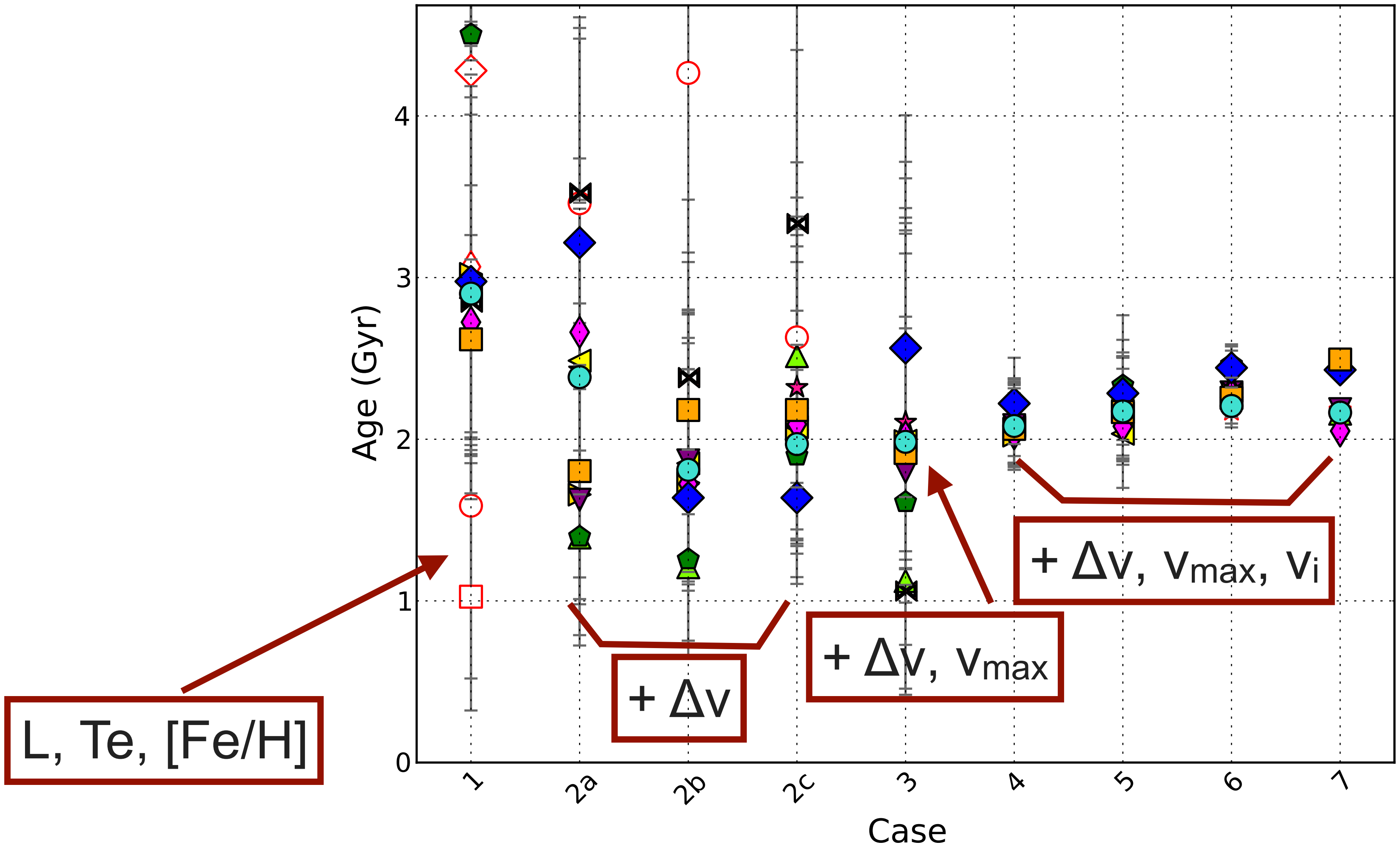
R ⇒ ± 2.2 %

Age ⇒ 25 %

M ⇒ ± 3.3 %

R ⇒ ± 1.1 %

Age ⇒ 15 %



Case	Observed	Adjusted	Fixed
1	$T_{\rm eff}$, L, [Fe/H]	A, M, $(Z/X)_0$	$\alpha_{\rm conv}$, Y_0
2a, b, c	$T_{\rm eff}$, L, [Fe/H], $\langle\Delta\nu\rangle$	A, M, $(Z/X)_0$, $\alpha_{\rm conv}$	Y_0
3	$T_{\rm eff}$, L, [Fe/H], $\langle\Delta\nu\rangle$, $\nu_{\rm max}$	A, M, $(Z/X)_0$, $\alpha_{\rm conv}$, Y_0	–
4	$T_{\rm eff}$, L, [Fe/H], $\langle\Delta\nu\rangle$, $\langle d_{02}\rangle$	A, M, $(Z/X)_0$, $\alpha_{\rm conv}$, Y_0	–
5	$T_{\rm eff}$, L, [Fe/H], $\langle r_{02}\rangle$, $\langle rr_{01/10}\rangle$	A, M, $(Z/X)_0$, $\alpha_{\rm conv}$, Y_0	–
6	$T_{\rm eff}$, L, [Fe/H], $r_{02}(n)$, $rr_{01/10}(n)$	A, M, $(Z/X)_0$, $\alpha_{\rm conv}$, Y_0	–
7	$T_{\rm eff}$, L, [Fe/H], $\nu_{n,\ell}$	A, M, $(Z/X)_0$, $\alpha_{\rm conv}$, Y_0	–

Set	Input physics	Figure symbol/colour
A	REF	circle, cyan
B	convection MLT	square, orange
C	AGSS09 mixture	diamond, blue
D	NACRE for ^{14}N(p, γ)^{15}O	small diamond, magenta
E	no microscopic diffusion	pentagon, red
F	Kurucz model atmosphere, MLT	bowtie, brown
G	B69 for microscopic diffusion	upwards triangle, chartreuse
H	EoS OPAL01	downwards triangle, purple
I	overshooting $\alpha_{\rm ov} = 0.15H_{\rm P}$	inferior, yellow
J	overshooting $M_{\rm ov,c} = 1.8 \times M_{\rm cc}$	superior, gold
K	convective penetration $\xi_{\rm PC} = 1.3H_{\rm P}$	asterisk, pink

Lebreton & Goupil, 2014, A&A

What do we (don't) know for sure about stellar physics ?

Diffusion

- is diffusion inhibited or not ??
- if yes, to which extent ? In which mass range?
- radiative acceleration at low Z only ??

→ Age reduction 40 %

Rotation

- problems with the helioseismic rotation profile
- problems with the rotation contrast in RG
- unknown process to transport angular momentum
- would it be better to ignore rotation ?

→ Age spread 40 %

Outer boundary conditions

- effects still not well understood
- 3D models can certainly help

Solar models for different atmospheric models adopted to obtain the outer boundary conditions

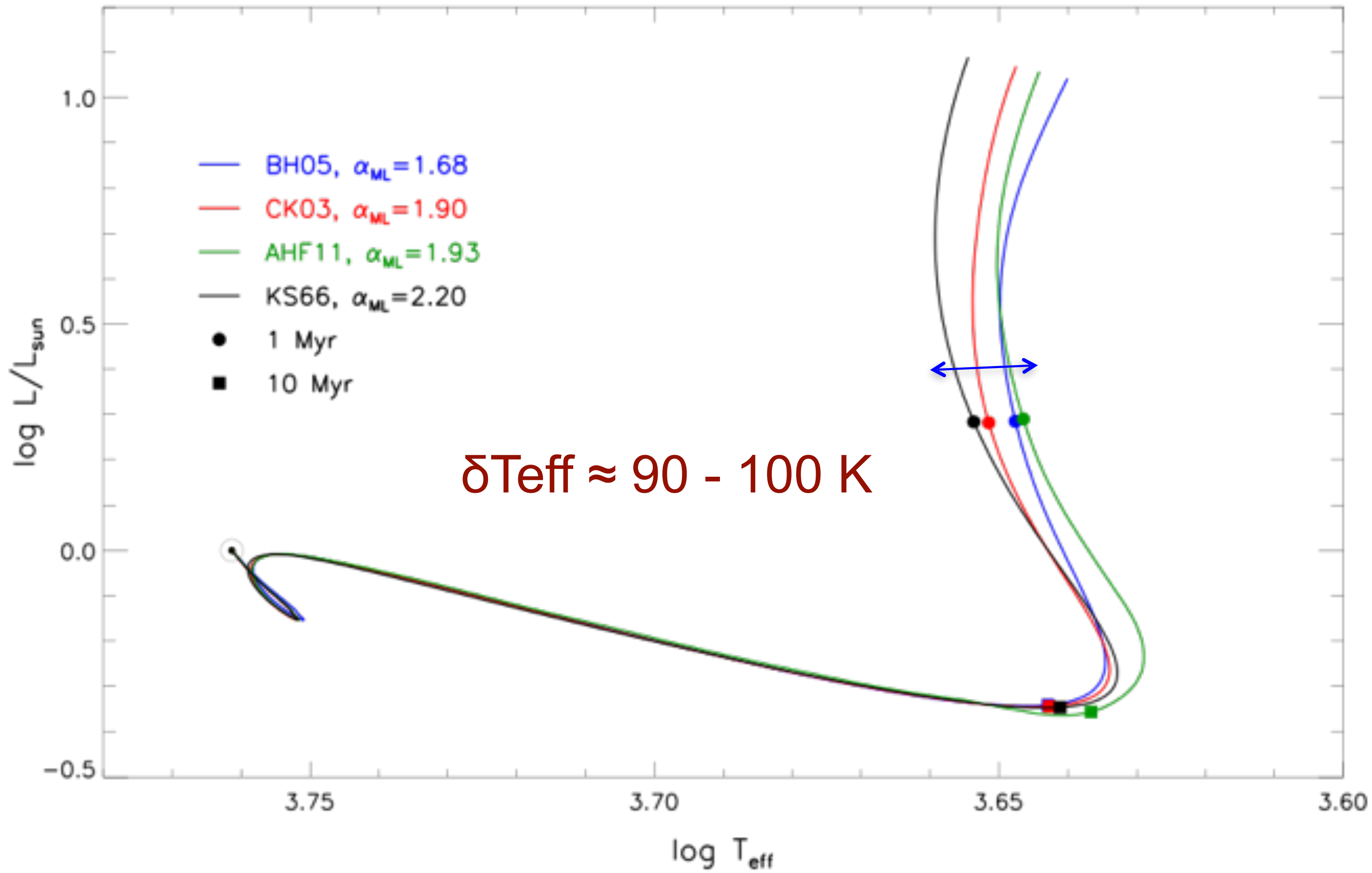


Figure 1.7: Comparison between 1 $M_\odot$ tracks computed adopting the solar calibrated value of α_{ML} as obtained from the adoption of the BH05, CK03, AHF11, and KS66 boundary conditions. The models corresponding to 1 Myr (filled-circle), 5 Myr (filled-triangle), 10 Myr (filled-square) and the position of the Sun ($\odot$) are also shown.

E. Tognelli, P. G. Prada Moroni, S. Degl'Innocenti, 2011, A&A, 533, A109

Age ⇒ ? %

Dwarfs

Semiconvection ?

Rotation ⇒ + 40 %

Diffusion ⇒ - 40 %

Rotation inhibits diffusion ⇒ + 40 %

No rotation ⇒ diffusion ⇒ - 40 %

} 40 %

l_{MLT} ⇒ 20-30 %

Te ⇒ ?

L ⇒ ?

ν_{max} ⇒ Δν/5 (/4, /3 ??)

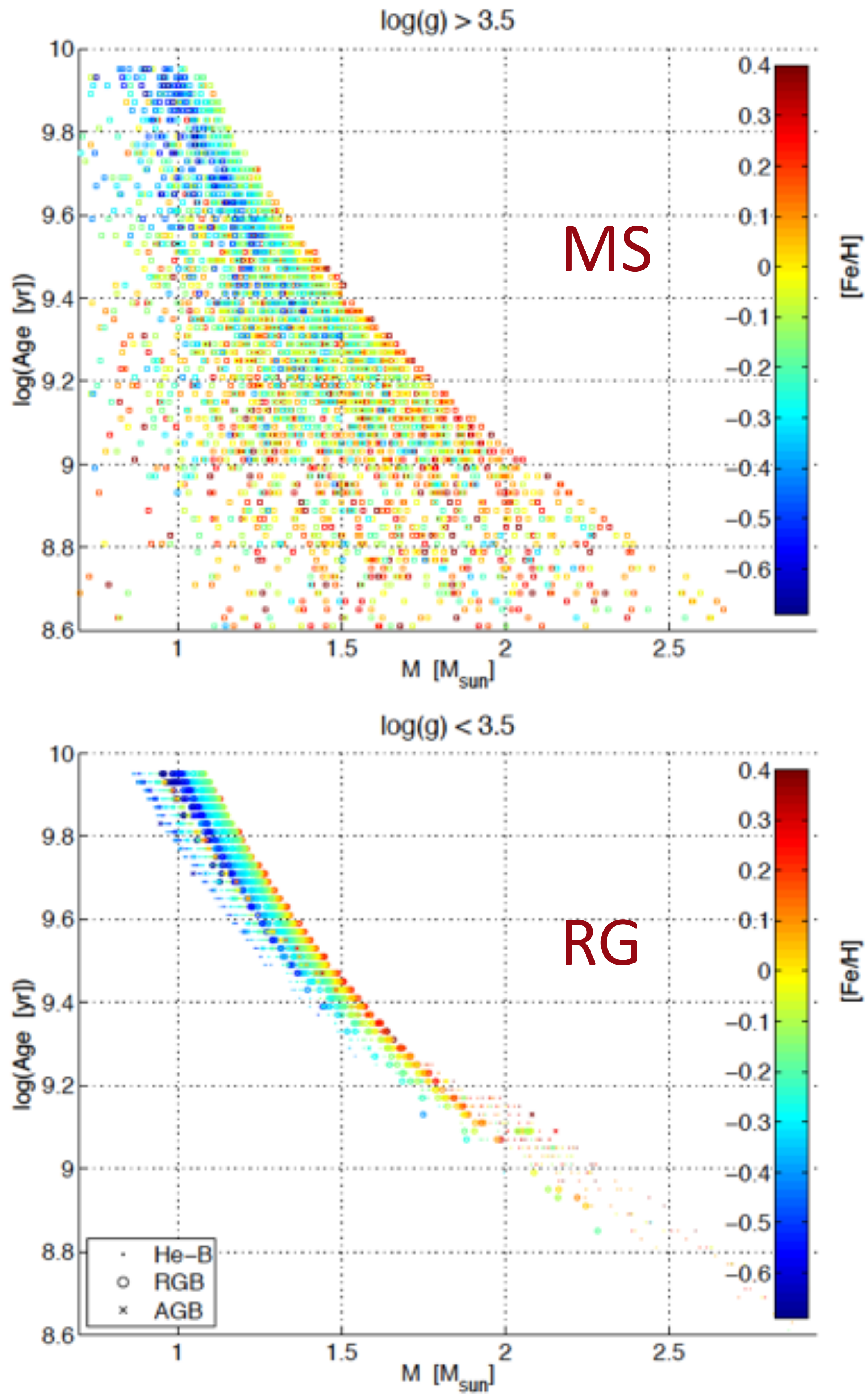
Calibration of the scaling relation?

20 + 40 + 30 + … ⇒ ~100 %

First good news : ages of low mass RG are much more robust than ages of low mass dwarfs

Diffusion :
40 % MS

Rotation :
40 % MS



Diffusion :
5 % RG

Rotation :
a few % RG

tight (age,mass) relation especially if Z is known

Miglio et al. 2011
Miglio et al. 2012

Second good news : There is still work to be done in stellar evolution !

Importance of model comparison

- different codes
- different time steps
- …

The importance of being cluster'st

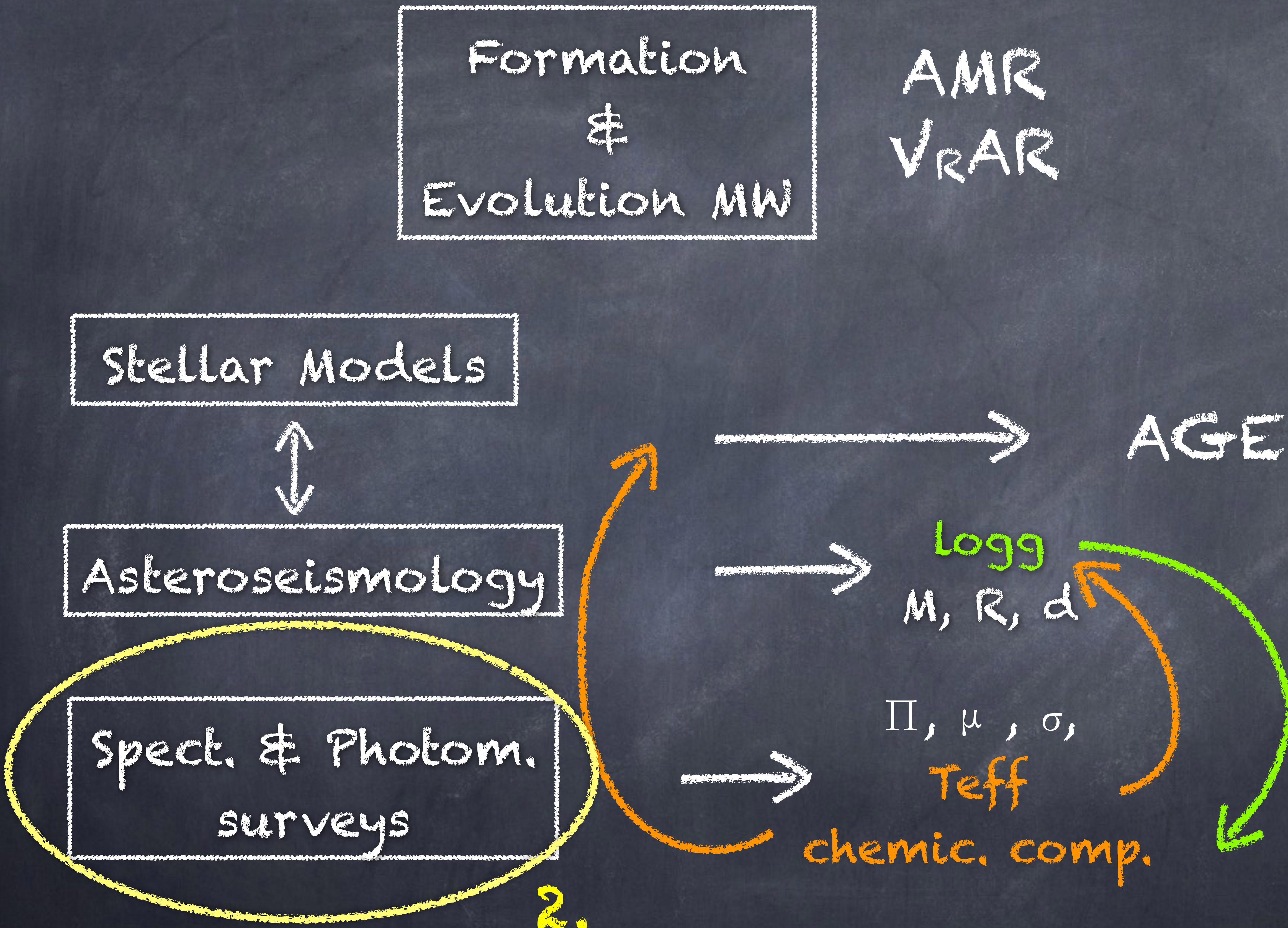
A case project for K2?

A case project for PLATO?

A case project for a dedicated new space mission

Stellar population synthesis

- Models ?
- SFR ?
- AMR ?
- Mass distribution
- Radius distribution ?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2. Spectroscopic and photometric surveys

- RAVE
- Gaia-ESO
- APOGEE
- GALAH
- Gaia
- LAMOST
- SAGA
- 4Most
- WEAVE

APOKASC
COROGEE
CoRoT-GESS
...

Spectroscopic surveys

- challenges:
  - one or multi pipelines ? how to manage the procedures and uncertainties computation for both choices
  - necessity : understand the needs from stellar modelers and from spectroscopic surveys

What precision do we need on Fe/H, X_i, M, R, age, … ?

- Stellar models
- Formation & evolution of the galaxy
  - thick disk/thin disk
  - AMR

An uncertainty of 25 % on the age is required from sismo

What is the precision required on Z from spectro surveys ?

Sesto table

Where are we NOW ?

Property	Uncertainty
R	5 %
M	10 %
Te	20-70 K $(Z_{\odot})^2$ - >>> at low Z
log g	0.15-0.20 dex[2]
L	depends on Π (Gaia), BC[4]
Y	$Y_{\odot,Helio} = 0.2485 \pm 0.0034$
Z	$Z_{\odot} = 0.014$[5]
age	40 %[1] - 20 % if Z and ev state are known
$\alpha_{e\text{-}m}$	?
α_{MLT}	?

[1] From scaling relations (see A. Miglio, J. Montalban and D. Stello, Sesto proceedings)
[2] T. Morel, private communication (see also T. Morel, Sesto proceedings)
[3] Molenda-Zakowicz et al. 2013, MNRAS 434, 1422
[4] Bruntt et al. 2010, MNRAS 405, 1907
[5] M. Asplund et al., see the discussion in Sesto proceedings

« Galactic »table

What would we like ?

Property	Uncertainty
R	%
M	%
Te	
log g	… dex
L	Π (Gaia)
Y	$Y = Y_{\odot,Helio} + ?$
[Fe/H]	[Fe/H] = 0.05 dex
[α/Fe]	[α/Fe] =
« good age »	30 % ?
V_R	?

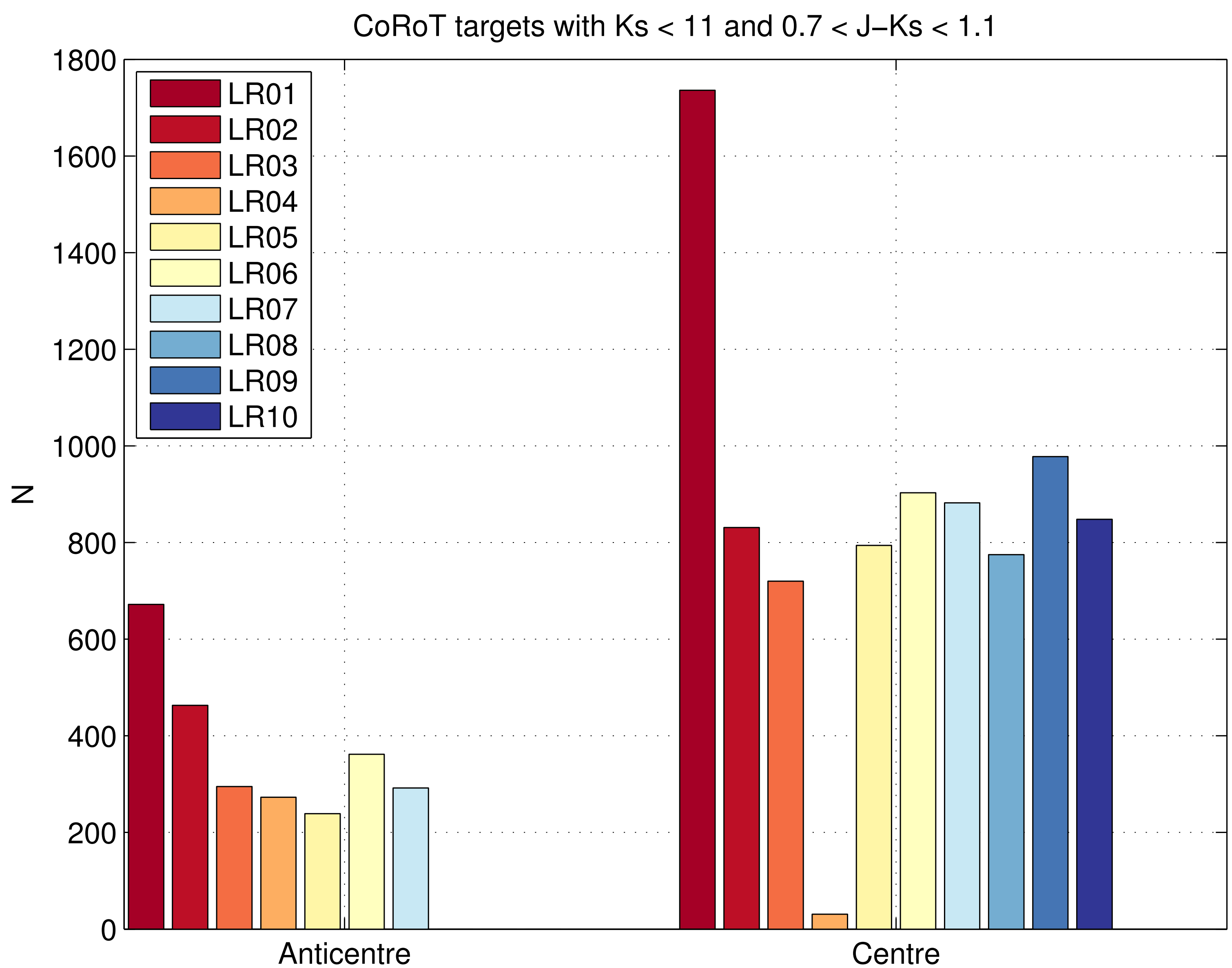
How do we organize ourselves ?

- CoRoT
- Kepler
- K2
- PLATO

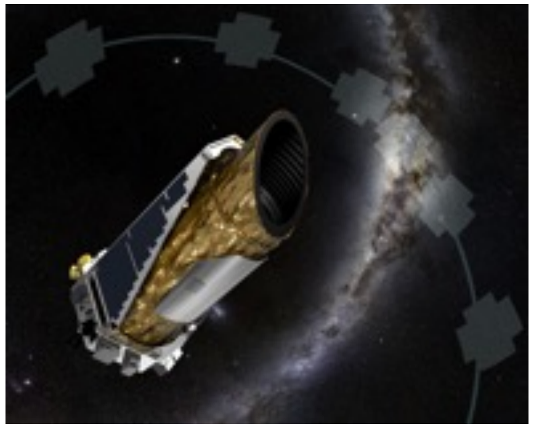
- RAVE
- Gaia-ESO
- APOGEE
- GALAH
- Gaia
- LAMOST
- SAGA
- 4Most
- WEAVE

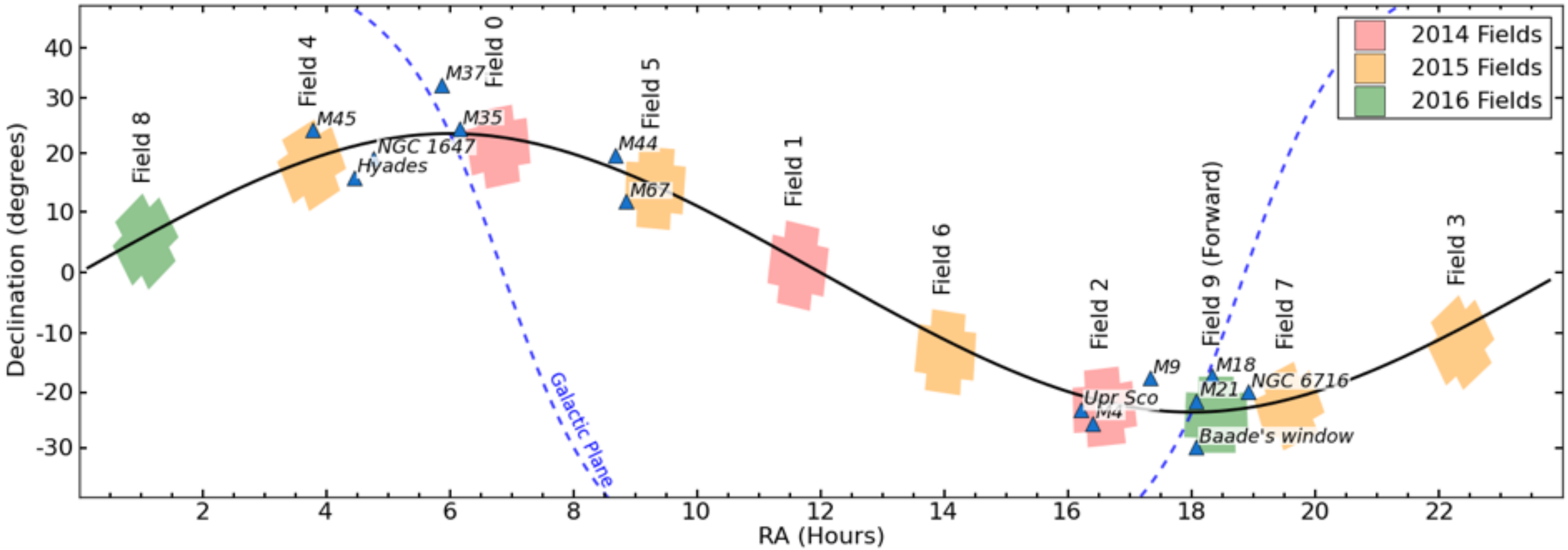
APOKASC
COROGEE
CoRoT-GESS
...

CoRoT targets still to be delivered



K2 fields





2014 Fields
2015 Fields
2016 Fields
Declination (degrees)
RA (Hours)
40
30
20
10
0
-10
-20
-30
2
4
6
8
10
12
14
16
18
20
22
Field 8
Field 4
Field 0
Field 5
Field 1
Field 6
Field 2
Field 9 (Forward)
Field 7
Field 3
M45
M37
M35
NGC 1647
Hyades
M44
M67
M9
M18
M21
NGC 6716
Upr Sco
M4
Baade's window
Galactic Plane


See you soon!