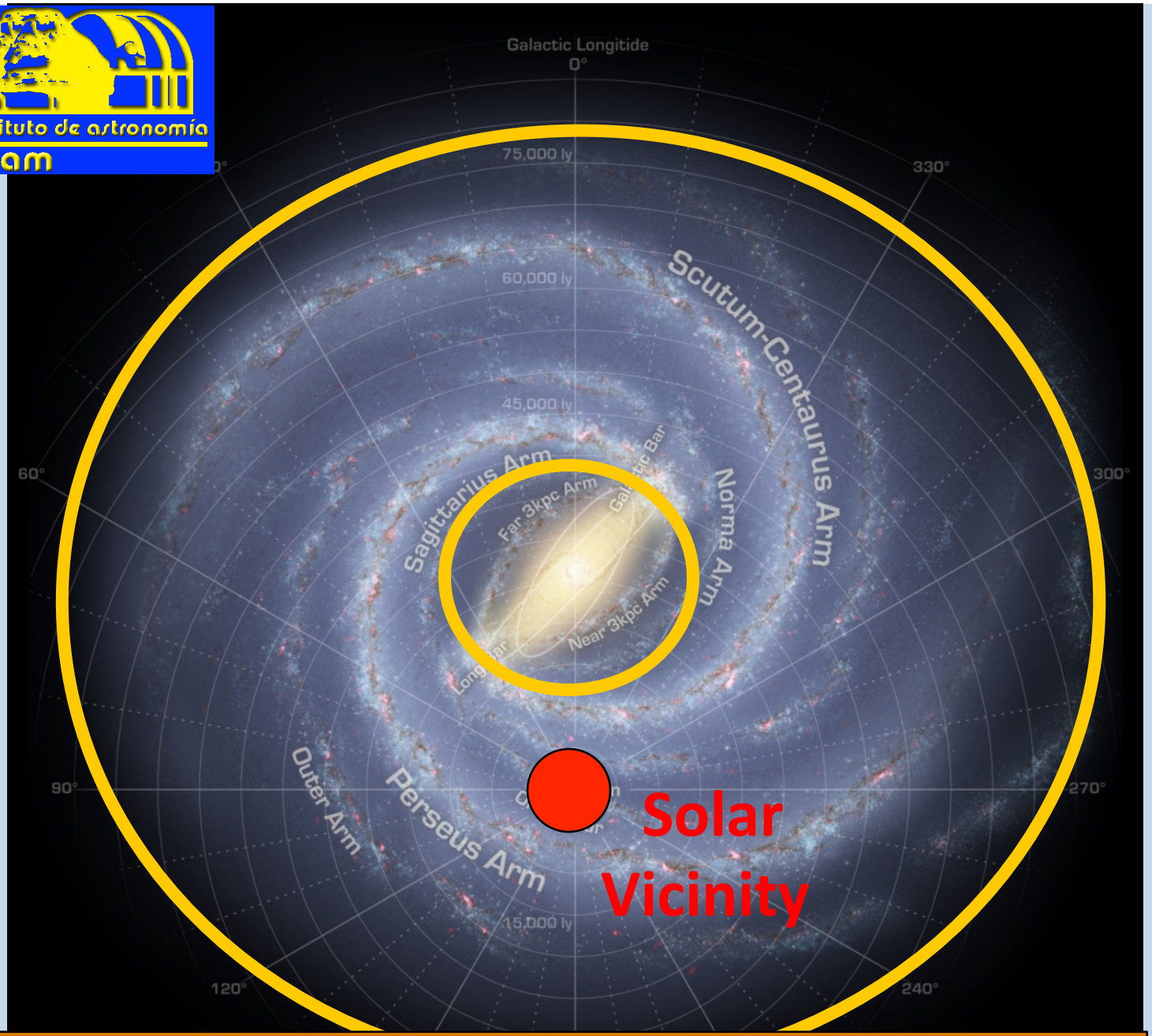
SOLAR OXYGEN



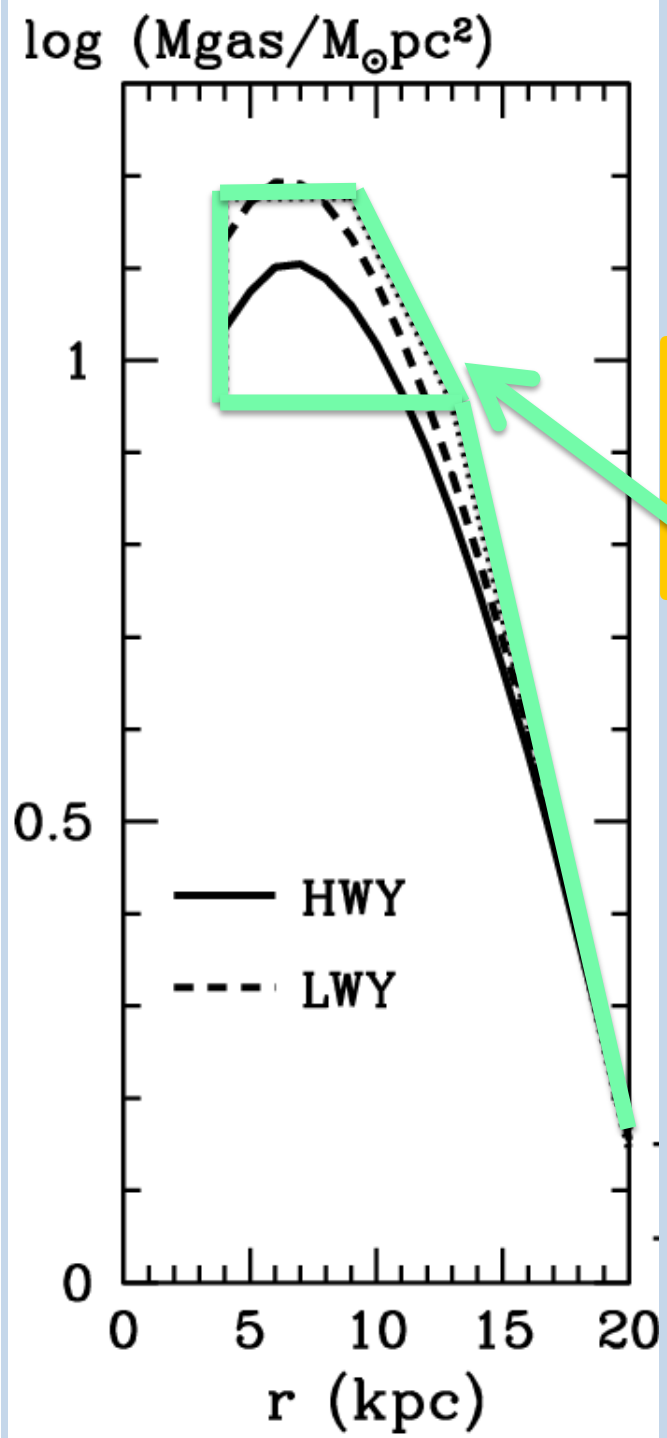
Carigi & Peimbert (2011) RMAA, 47, 139

SUN'S ORIGEN

Introduction

- Comparing chemical evolution models for the **Galactic disk** with abundances of:
    1. HII regions and B stars (present-time)
    2. Protosolar abundances (4.5 Gyr ago)
    3. F-G stars (different ages) of the **Solar Vicinity**

- Find the answers:
    A. **Where did Sun form**?
    B. Well mixed or rich material?



Chemical Evolution Model of *Galactic disk*. Present-time Mgas

Models built to reproduce:

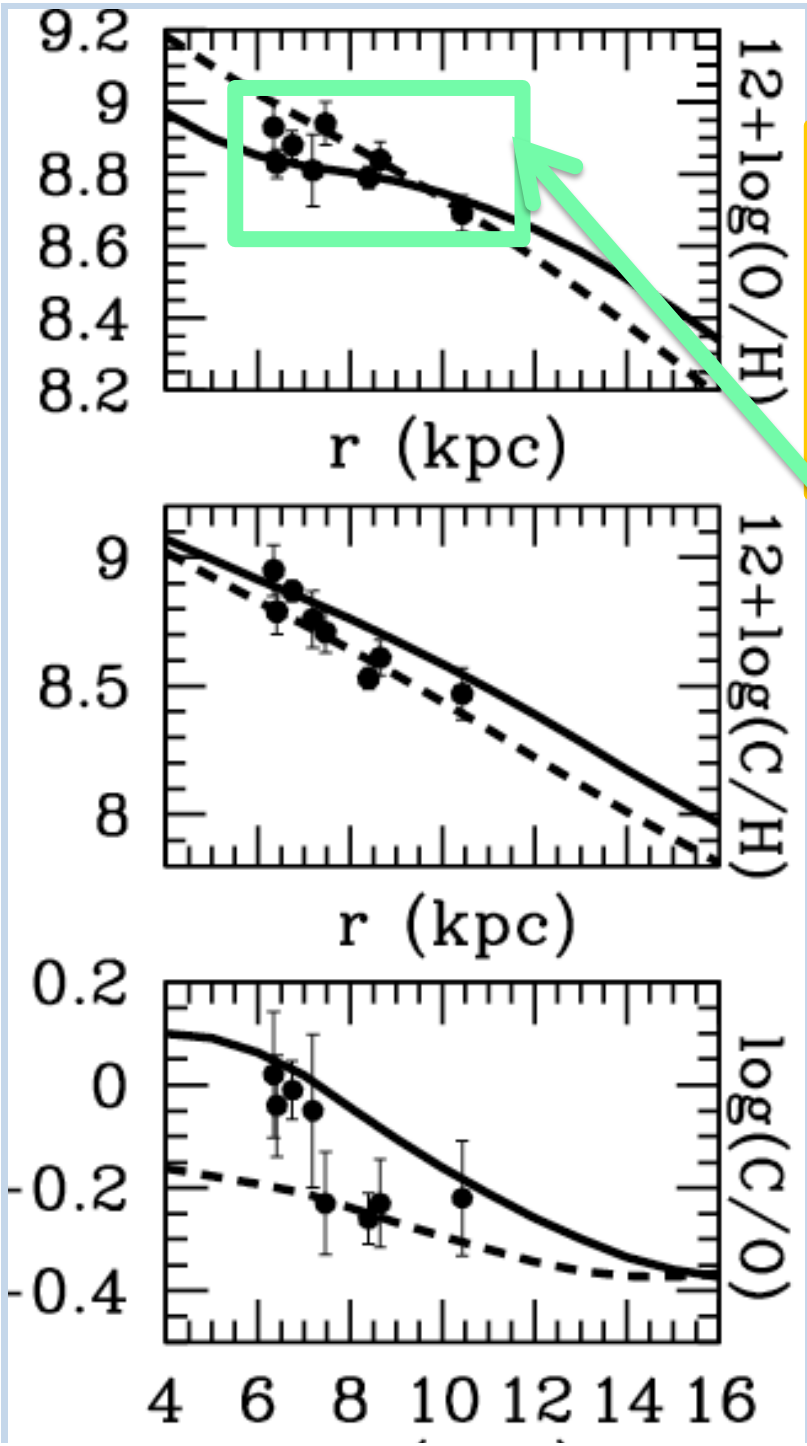
A) $M_{tot}(r) = 50\ M_{\odot}pc^{-2}\ \exp(-(r-r_{\odot})/3.5\text{kpc})$

B) Present-day gas mass distribution (H,He,*Z*)

Chemical evolution models:

1. Galactic formation: inside-outside scenario.

2. SFR (r,t): Kennicutt-Schmidt law.



CEM. Present-time C and O.

Models built to reproduce:

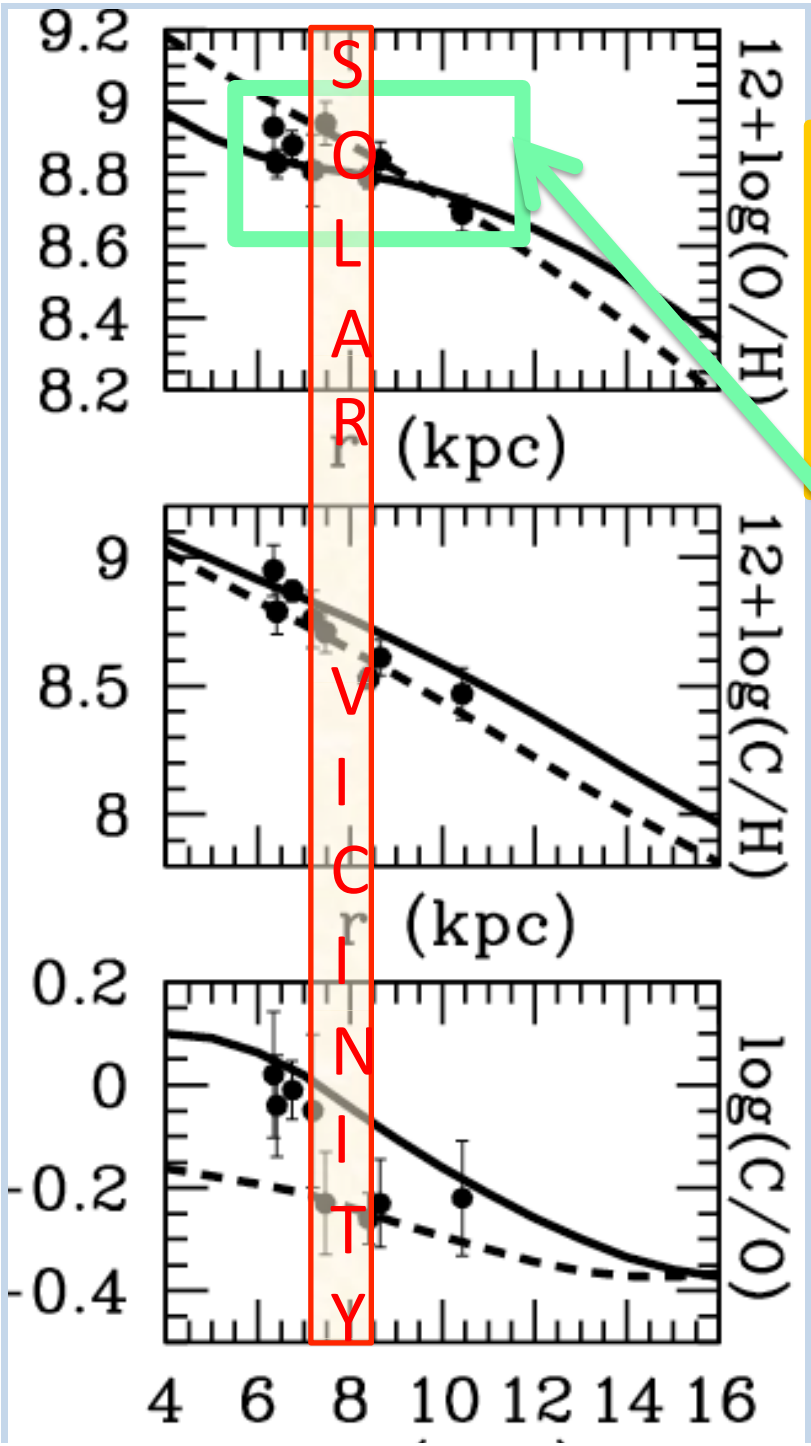
C) Present-day O/H gradient

Recombination lines + dust depletion (García-Rojas & Esteban 2007, Esteban et al. 1998, Mesa-Delgado et al. 2009, Peimbert & Peimbert 2010)

Chemical evolution model:

3. IMF (m). Kroupa et al (1993). 0.1 - 80 $M_{\odot}$.

4. *Z* - dependent stellar yields:
   a. LIMS. Marigo´s works (He, C)
   b. SNIa. Thielemann et al. (1993). (Fe)
   c. MS. Geneva group (rotation + stellar winds). (He, C, O)



CEM. Present-time C and O.

Models built to reproduce:

C) Present-day O/H gradient

Recombination lines + dust depletion (García-Rojas & Esteban 2007, Esteban et al. 1998, Mesa-Delgado et al. 2009, Peimbert & Peimbert 2010)

Chemical evolution model:

ONLY DIFFERENCE CEM models:

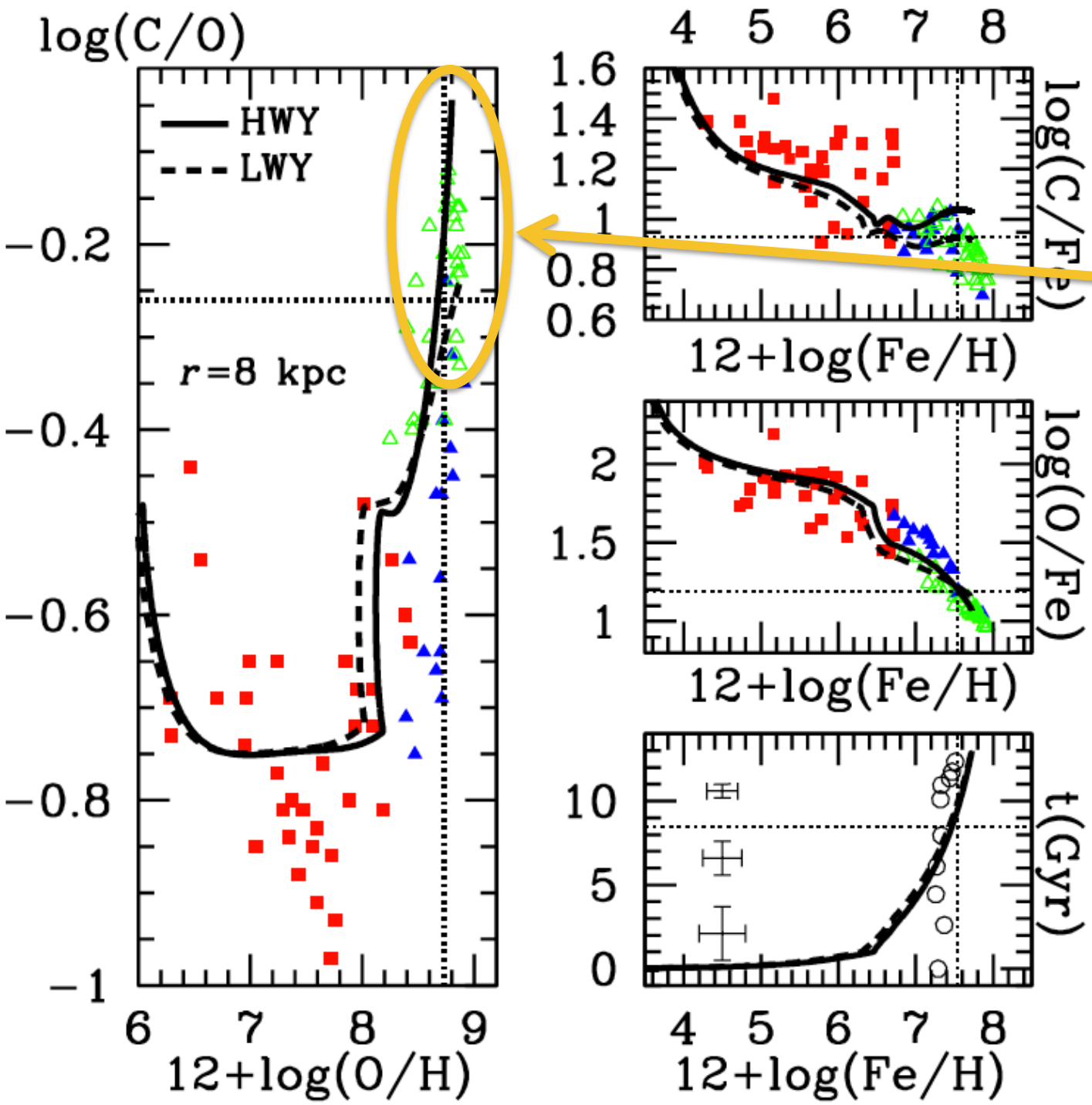
Mass-loss rate due to stellar winds by **massive stars** with $Z = 0.02$ ($W \alpha Z^{0.5}$)

HWY : High wind yield (Maeder 1992). High C and low O

LWY : Low wind (Hirschi et al. 2005). Low C and high O

Important Notice:

Models have NOT been forced to fit the protosolar abundances!!!!!



CEM.
C, O, Fe , time
Solar Vicinity

IWY=(HWY +LWY)/2

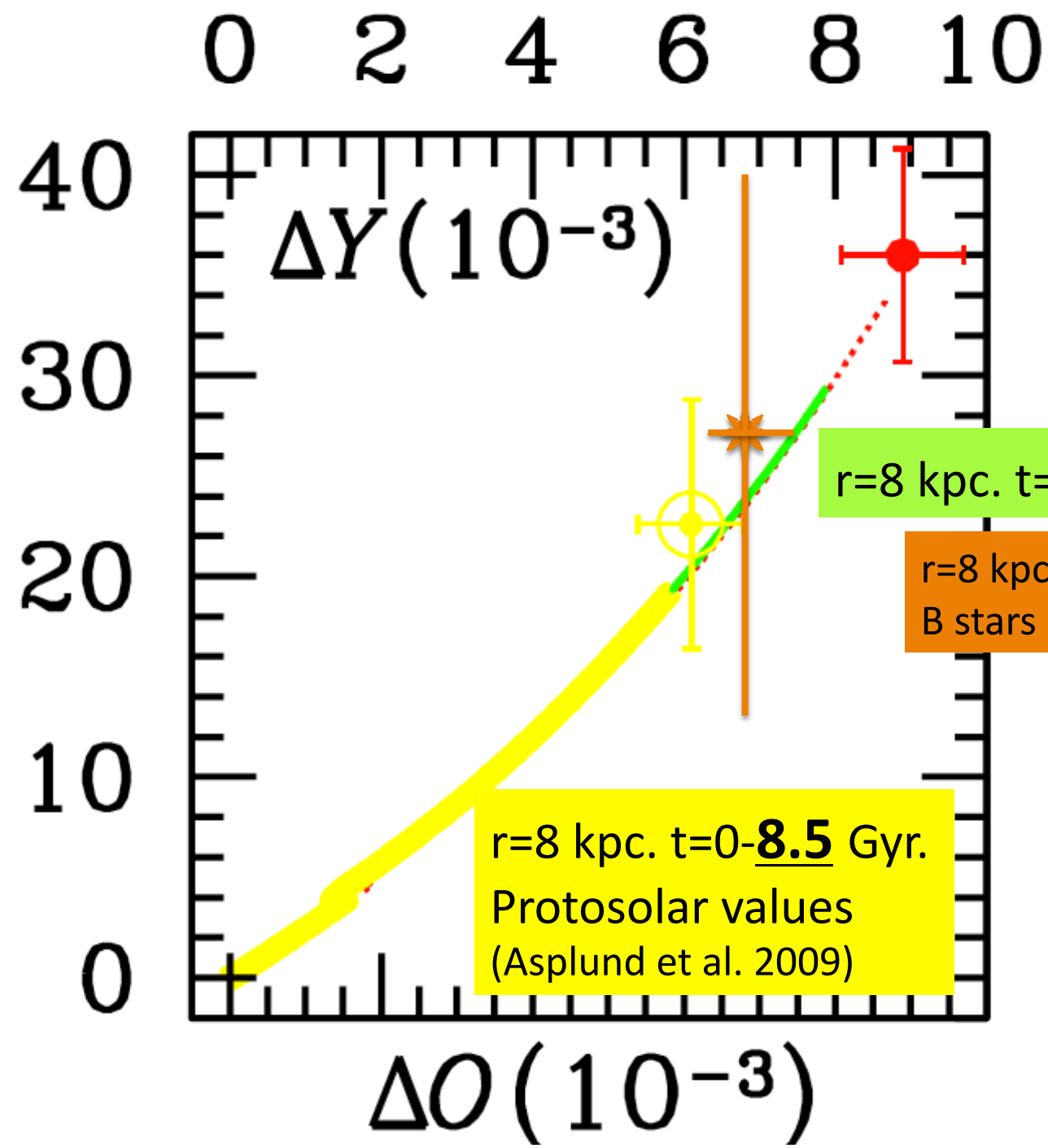
Stellar abundances:

- **Halo** (Akerman et al. 2004)
- **Thick** & **thin** disk (Bensby & Feltzing, 2006)

- Mean ages & Fe/H of disk stars (Nordstrom et al. 2004)

- Protosolar abundances at =8.5 Gyr (Asplund et al. 2009)

He and O evolution
r= 7 & 8 kpc



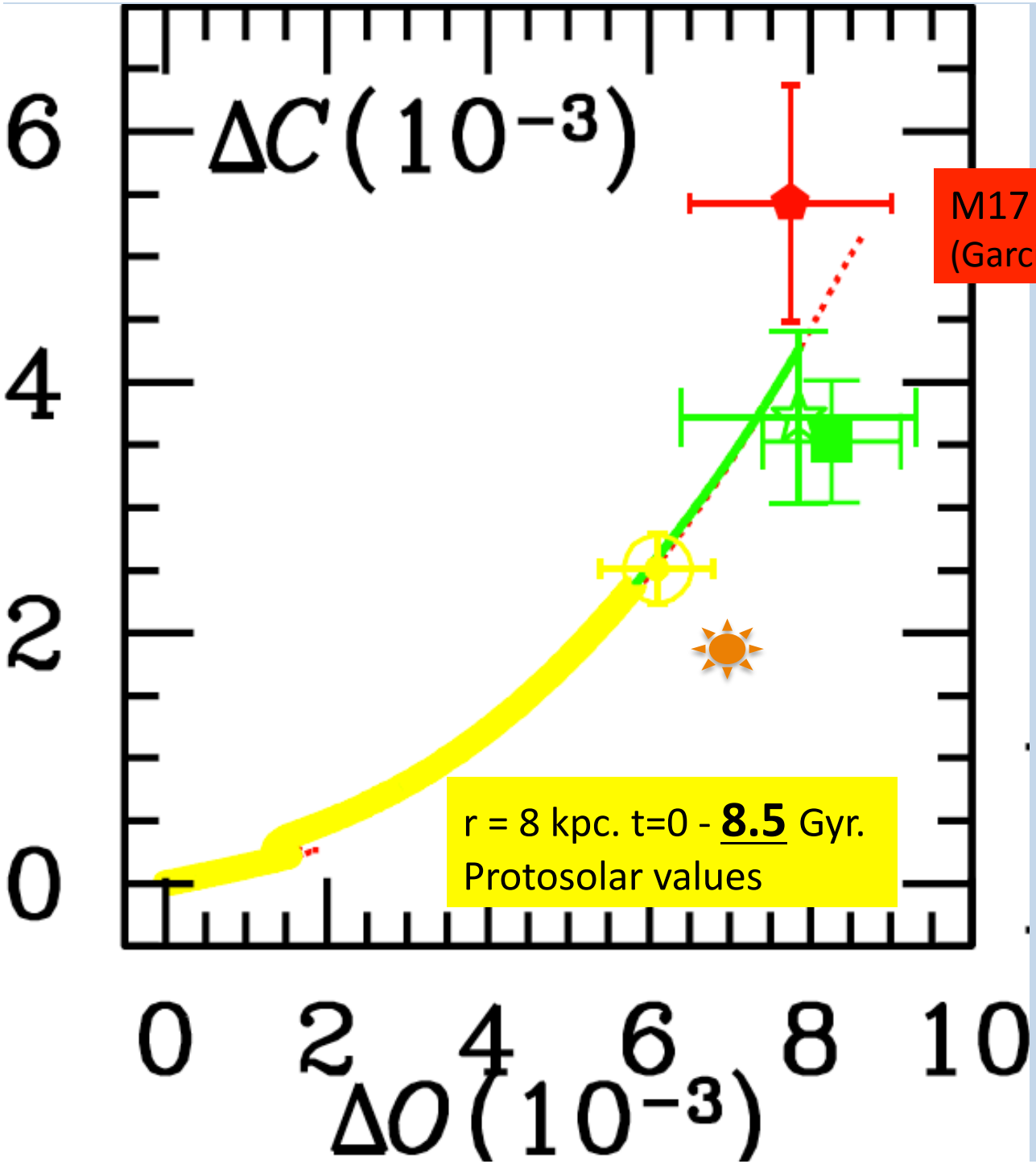
r=7 kpc. t=0-13 Gyr.
HII region. M17
(Carigi & Peimbert, 2008)

r=8 kpc. t=0-**13** Gyr.

r=8 kpc. t=**13** Gyr.
B stars (Nieva & Przybilla, 2012)

r=8 kpc. t=0-**8.5** Gyr.
Protosolar values
(Asplund et al. 2009)

IWY=(HWY +LWY)/2



C and O evolution
r = 7 and 8 kpc

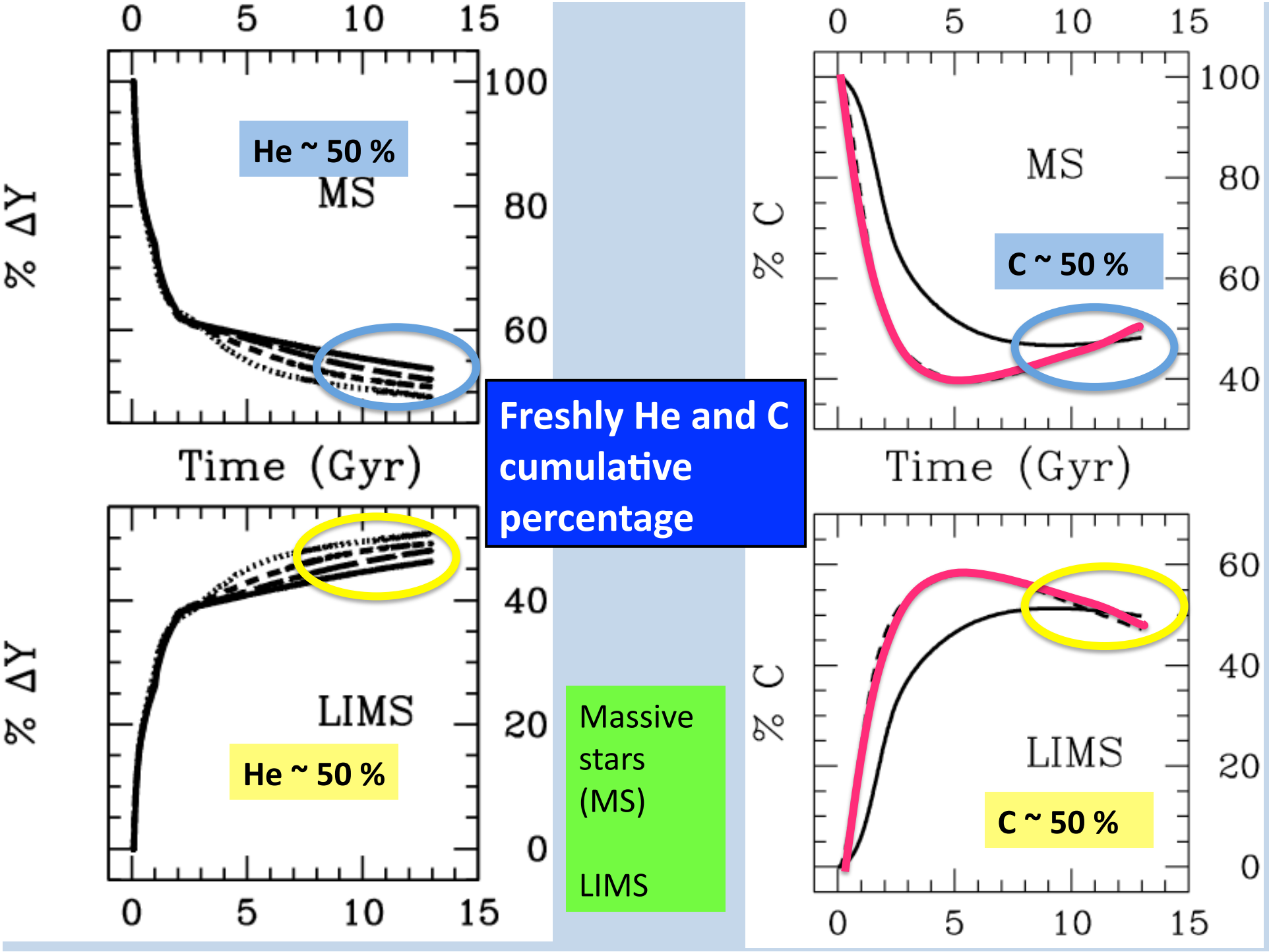
M17 & M20. r=6.75 & 7.19 kpc (García-Rojas &Esteban, 2008)

r=8 kpc. t=0-**13** Gyr.

1. F-G dwarfs (Bensby & Feltzing, 2006)
2. NGC 3576 + Orion (7.46 +8.40 kpc, GR08)

r=8 kpc. t=**13** Gyr
B stars (Nieva & Przybilla 2012)

IWY=(HWY +LWY)/2



Freshly He and C cumulative percentage

CONCLUSIONS He,C,O,Fe vs time

Abundance determinations:

- from recombination lines
- + Correction by dust depletion:
  - ✓ 20% (0.08 dex) for O
  - ✓ 25% (0.10 dex) for C

- **Moderate mass loss rate for massive stars of $Z_{\odot}$**

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CONCLUSIONS He,C,O,Fe vs time

- ***Sun was originated:***
  of a well mixed material

Since~ **1/2 of the freshly He (and C) is produced by MS and 1/2 by LIMS**, and an important fraction of the **Fe comes from SNIa**, the agreement of the **He/O, C/O, and Fe/O** ratios between the **model and** the **protosolar abundances** implies that the Sun formed from a well mixed ISM.

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CONCLUSIONS He,C,O,Fe vs time

- ***Sun was originated:***
  at a galactocentric distance similar to that of the solar vicinity ***(6.8 - 8.4 kpc)***

Due to the good agreement of our model with the **protosolar abundances** and the **Sun-formation time.**

"…the Sun has migrated outwards … from a birthplace at a distance around **5-6 kpc** from the Galactic Centre." **(Nieva & Przybilla, 2012)**

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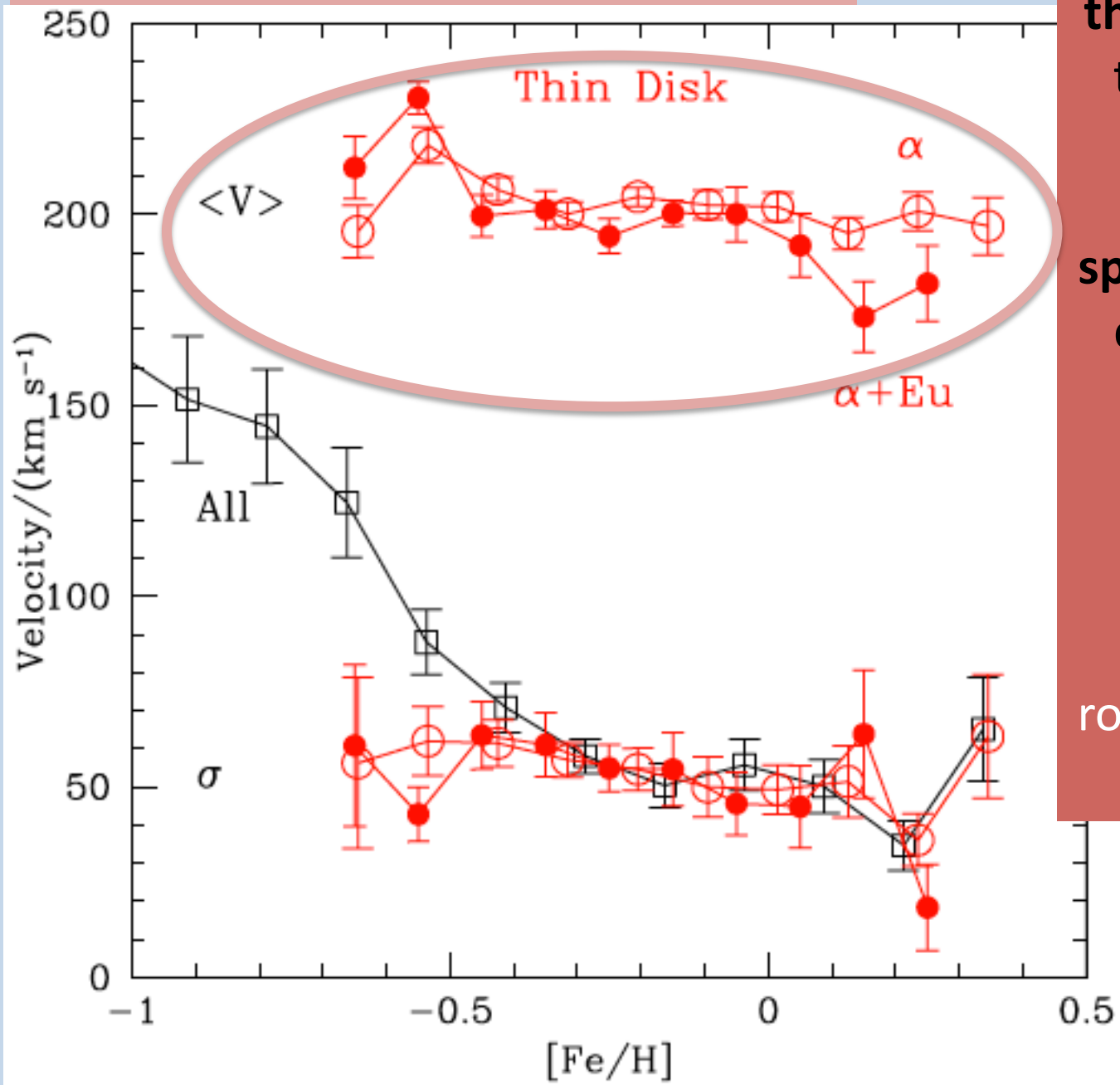
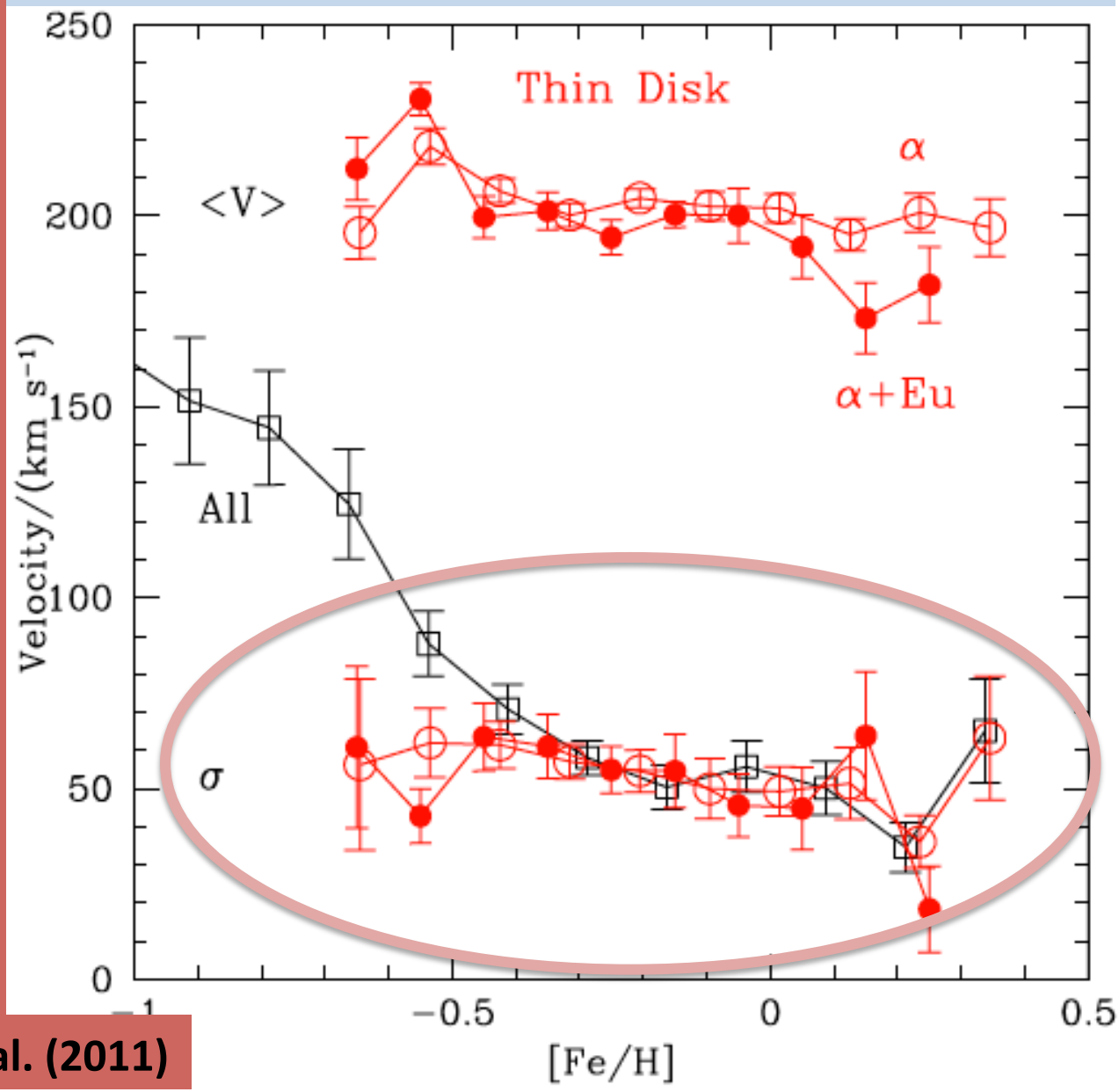
RADIAL MIGRATION ?

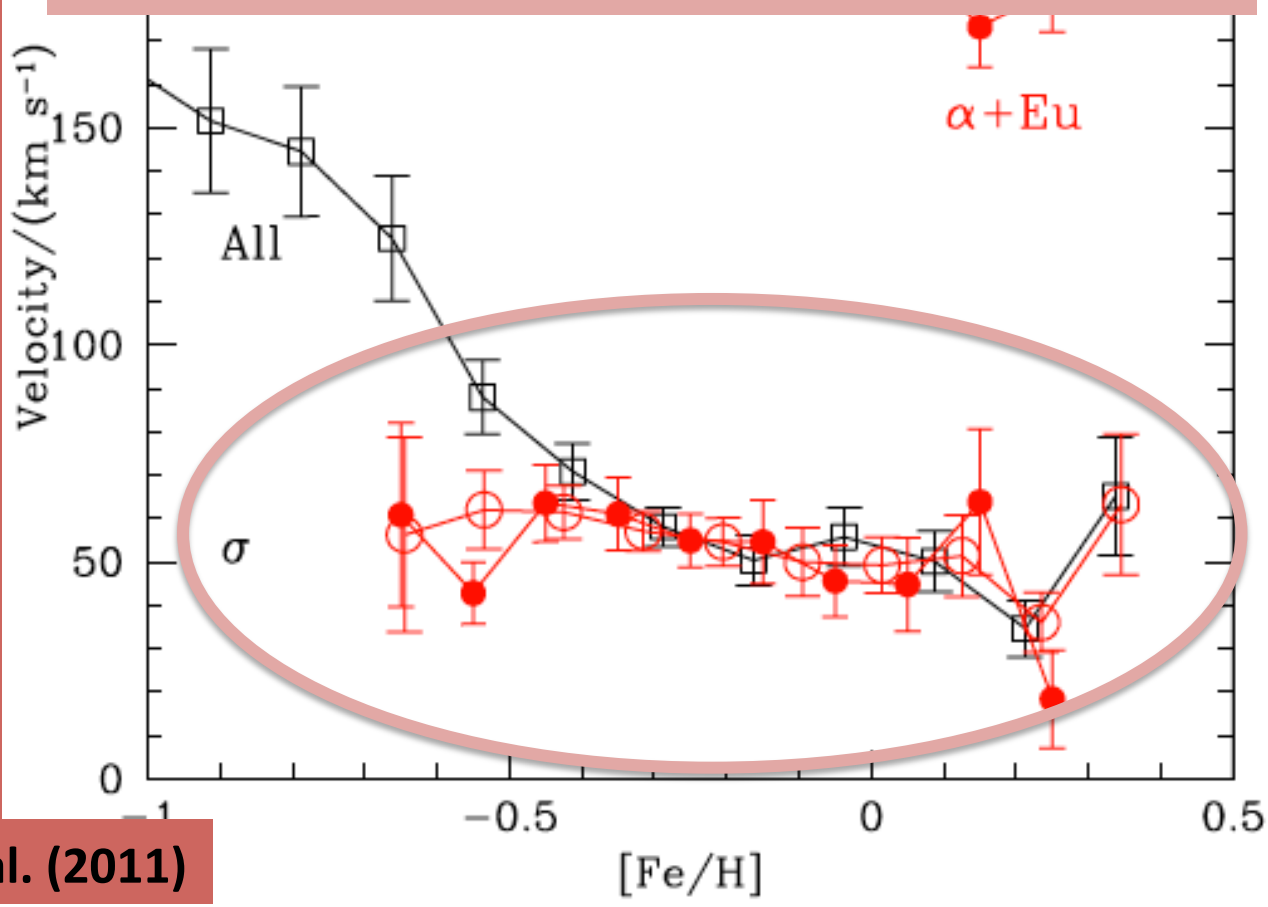


"… the **kinematics of thin disk** stars is found to be independent of metallicity: their **average rotation speed** remains roughly constant in the range −0. 7< [Fe/ H]< +0. 4, **a result that argues against radial migration** having played a substantial role in the evolution of the **thin disk".**

Navarro et al. (2011)

"The **velocity dispersion of the thin disk** is also independent of [Fe/H], implying that the increase in velocity dispersion with decreasing metallicity is the result of the increasing prevalence of the thick disk at lower metallicities, **rather than of the sustained operation of a dynamical heating mechanism".** **Navarro et al. (2011)**



The stellar radial migration, in the thin disk, may not be as important as some authors claim (Schonrich & Binney 2006, Roskar et al 2008, Sánchez-Blázquez et al 2009,.....)

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