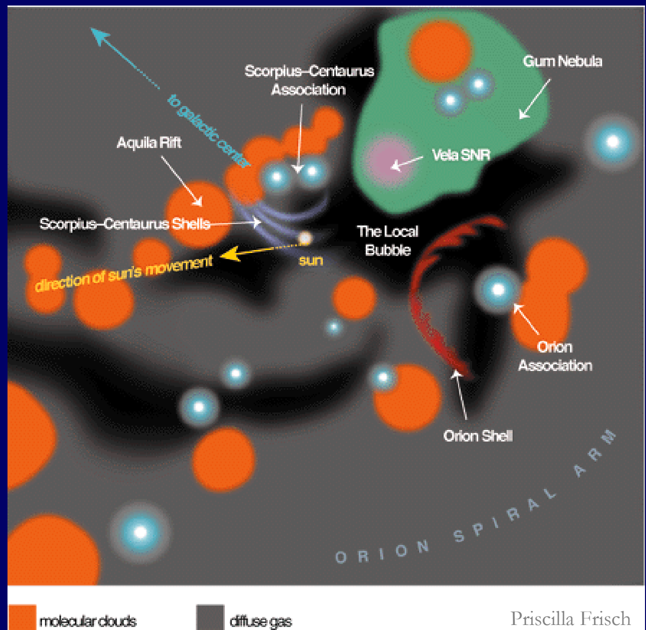
FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG
NATURWISSENSCHAFTLICHE FAKULTÄT

ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

Present-day cosmic abundances in the solar neighbourhood and implications



Fernanda Nieva

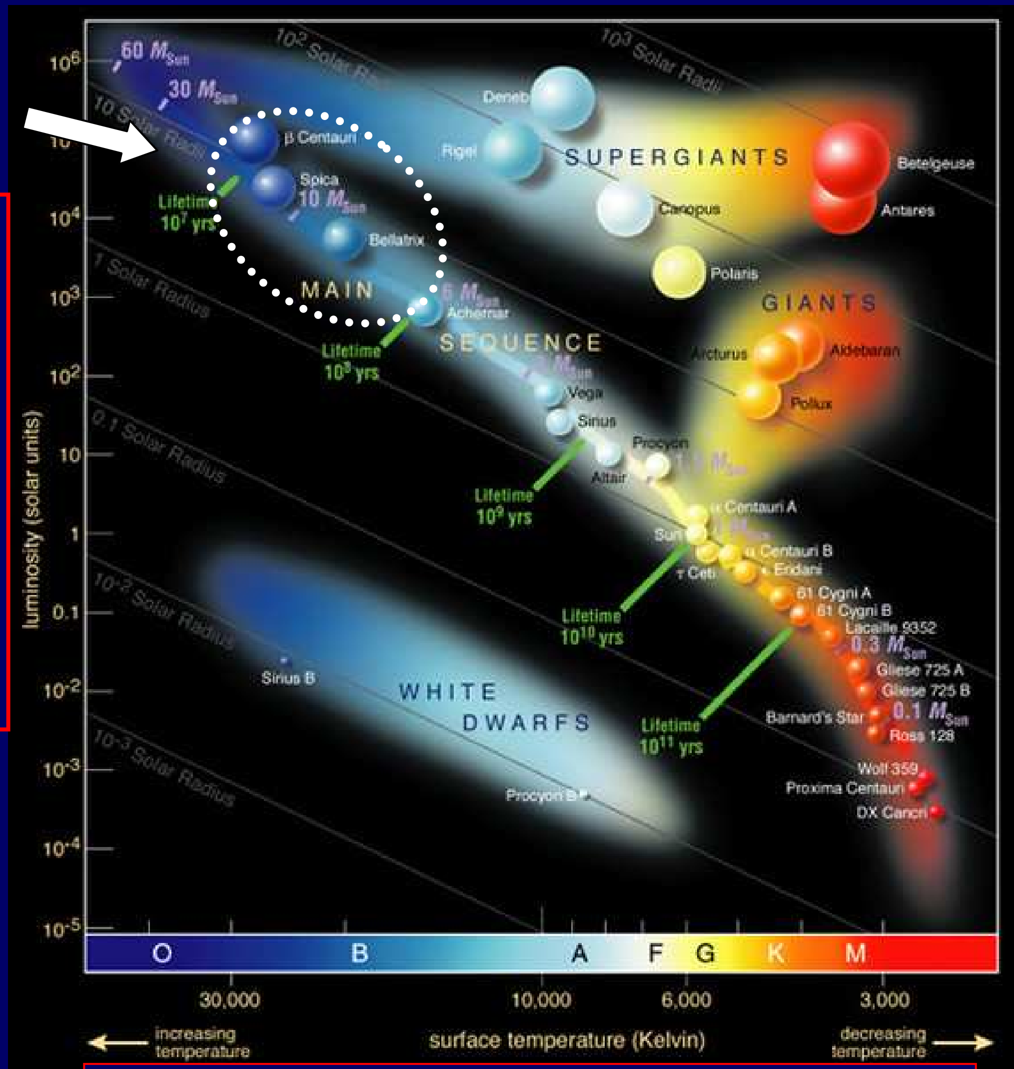
Norbert Przybilla

OB (late O/early B)-type stars: reliable indicators for *present-day* and spatial *(birth-place)* information on chemical abundances

Present-day abundances in the context of galactic evolution

OB-stars (O9-B2)

Main Sequence



Young: age ~10^7 yr

Massive: M ~9-20 M_{sun}

Hot: T_{eff} ~20-33 x10^4 K

Luminous: L~10^4-10^5 L_{sun}

absolute chemical composition (independently from e.g. solar values)

Early B-type stars	Older stars (e.g. Sun)
short lived (~10 Myr) → present-day no migration (pc) → birth place	long lived (~Gyr) → effects of GCE migration (kpc) → away from birth place
very bright in the optical → large distances simple atmospheres → 1D, radiative envelope, no chromosphere simple optical spectrum → ~hundred metal lines	fainter in the optical → shorter distances complex atmospheres → 3D, convective envelope, chromosphere complex optical spectrum → ~million lines

Early B-type stars	ISM / HII regions
no depletion into dust	depletion into dust

Early B-type stars	Late B-type stars
no diffusion	diffusion

Early B-type stars	O stars, B SGs
weak winds	strong winds

Chemical abundances of early B-type stars

Past decades	Recently (e.g. Nieva et al./Simon-Diaz et al.)
large uncertainties (~factor 2)	high precision and accuracy (~ 25%)
large spread (>factor 10)	small spread (~10%, ~ISM)
metal-poor compared to older stars like Sun	similar abundances than older stars like Sun
dubious abundance indicators	reliable abundance indicators

Classical model atmospheres

plane-parallel, hydrostatic & radiative equilibrium, LTE

Hybrid non-LTE approach:

OK for OB main sequence stars

(Nieva & Przybilla 2007 A&A)

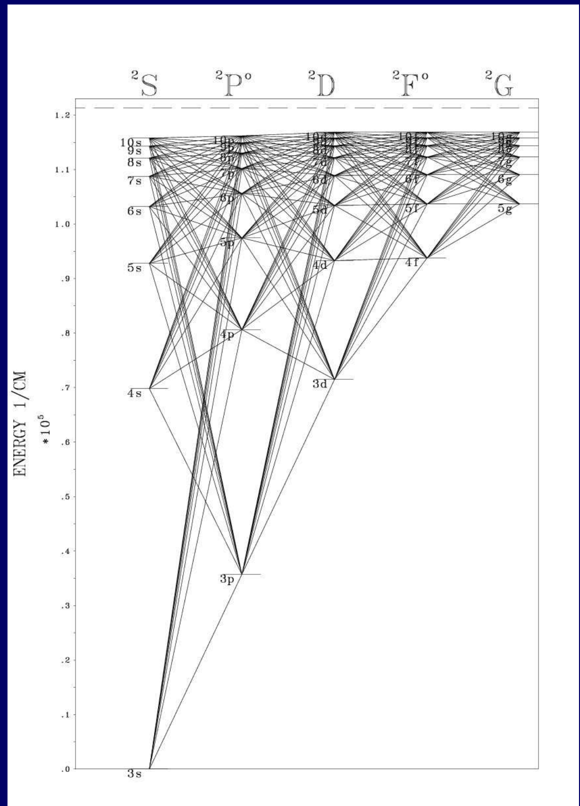
Non-LTE line formation

radiative transfer & statistical equilibrium

- Level populations: DETAIL
- Formal solution: SURFACE

(Giddings, 1981; Butler & Giddings 1985; updated by K. Butler, LMU)

- **Model atoms**



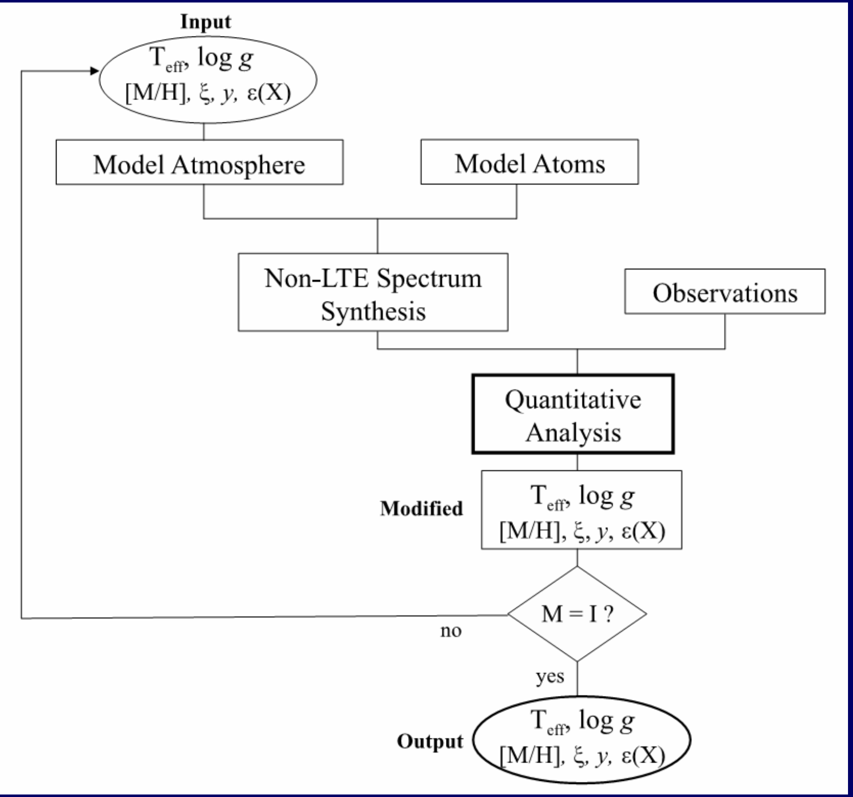
H (Przybilla & Butler 2004)

He I/II (Przybilla 2005)

C II/III/IV (Nieva & Przybilla 2006 ApJL, 2008 A&A)

O, N, Mg, Al, Ne, Fe & others (Munich group'90s + N. Przybilla + K. Butler)

Our self-consistent spectral analysis



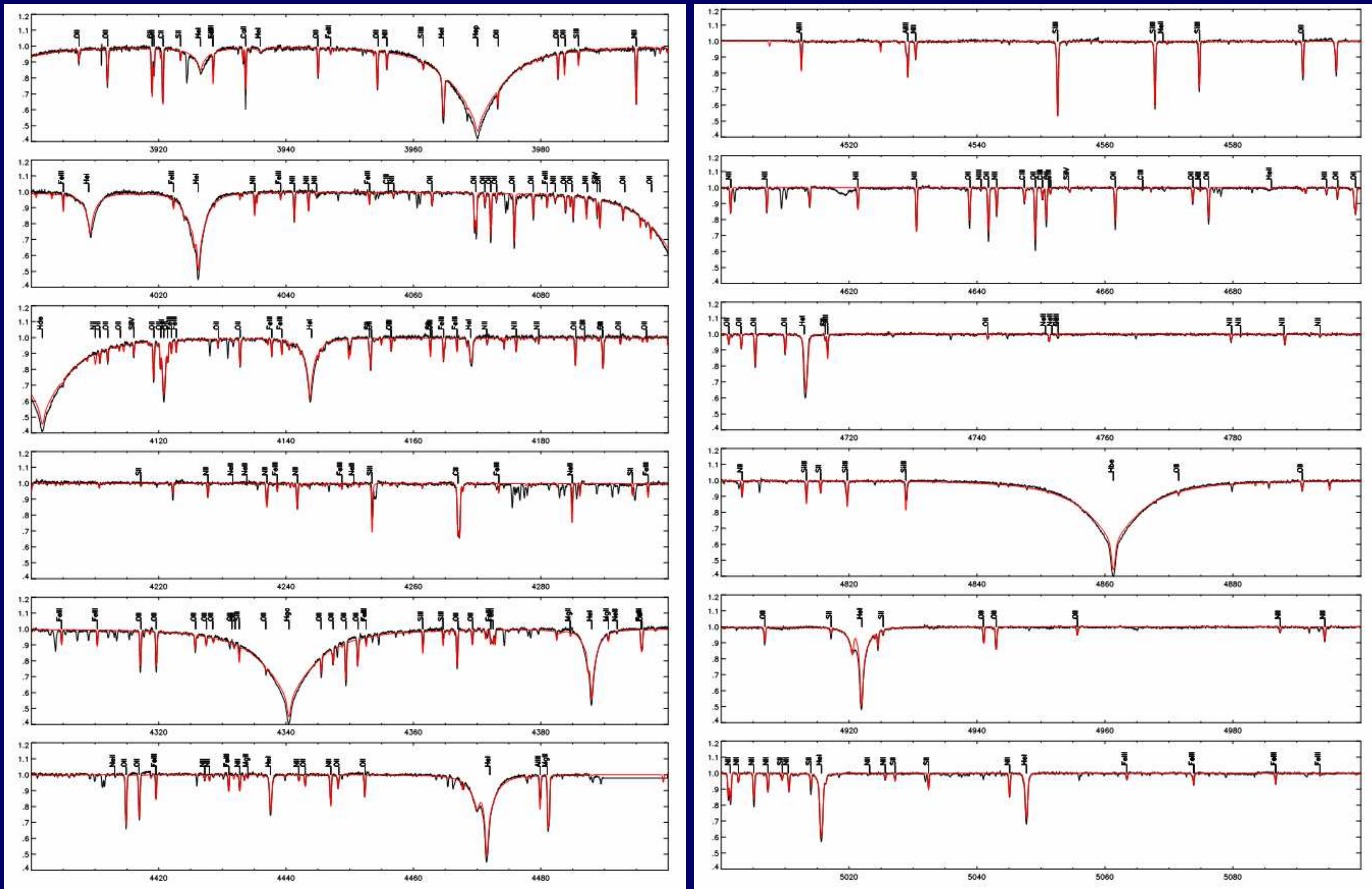
Goal

reproducing the whole observed spectrum with 1 set of parameters only ☺

Multiple metal ionization equilibria

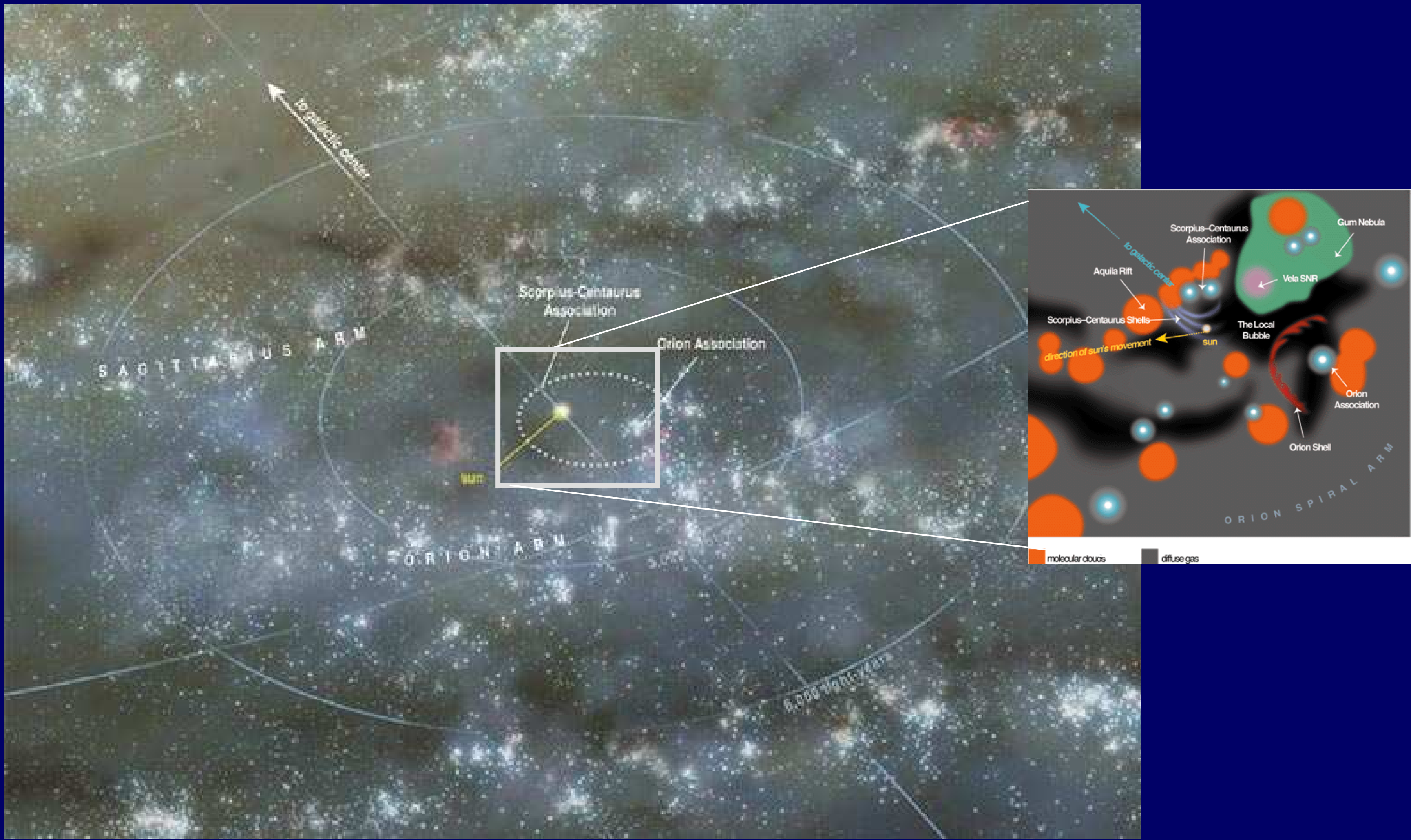
Result: simultaneous atmospheric parameters & chemical abundances @ high precision (reduced systematic effects)

Fits to all modeled lines (3800-5100 Å)



Nieva & Przybilla 2012, A&A, 539, A143
Nieva & Simon-Diaz 2011, A&A, 532, A2

Early-B stars in the solar neighborhood



Example: present-day oxygen abundance in the solar neighbourhood

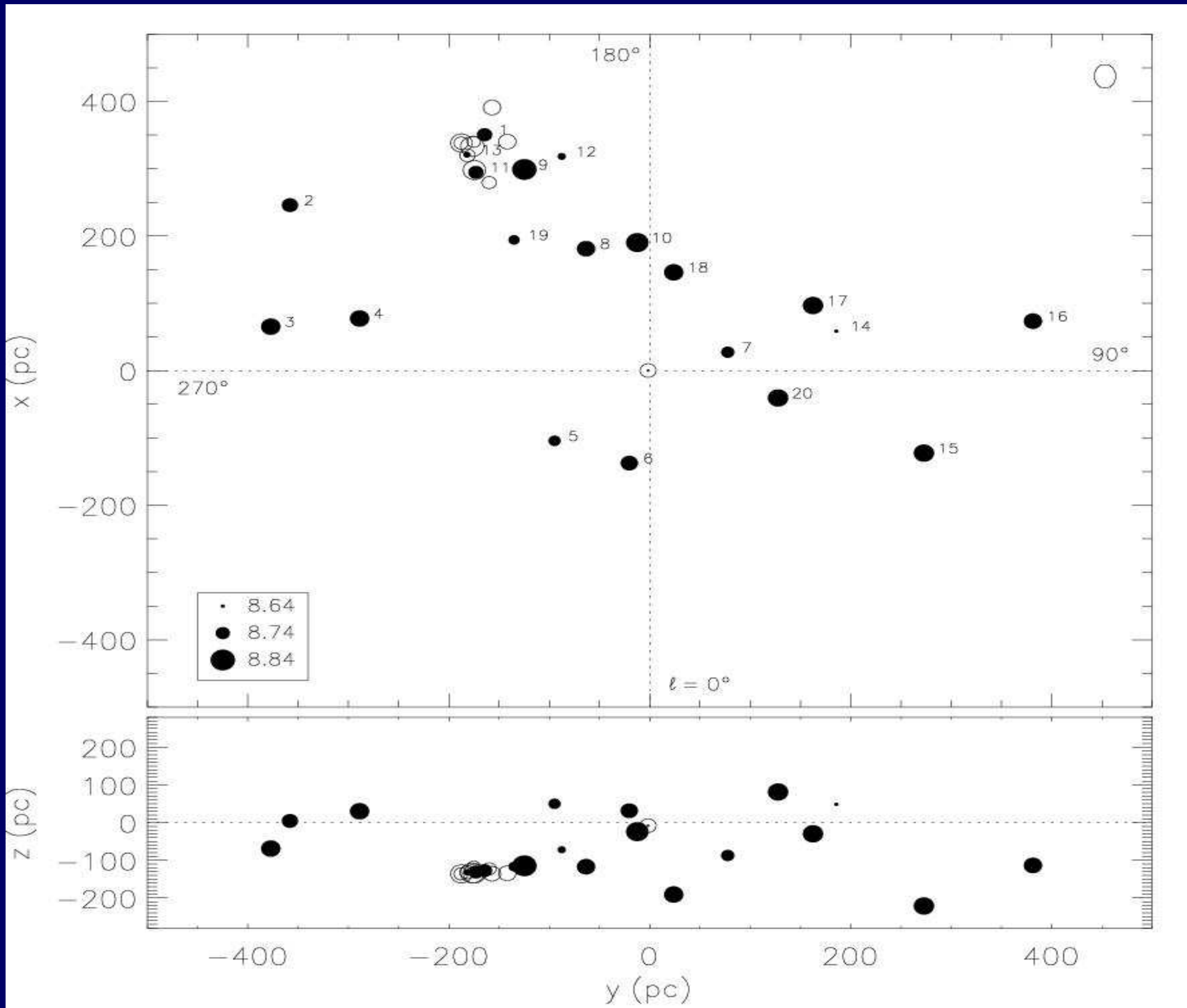
29 single stars

Up to 55 lines per star:
2 OI triplets (6155, 7774 Å)
~50 OII lines

OI/II ionization equilibrium

The same for several other elements

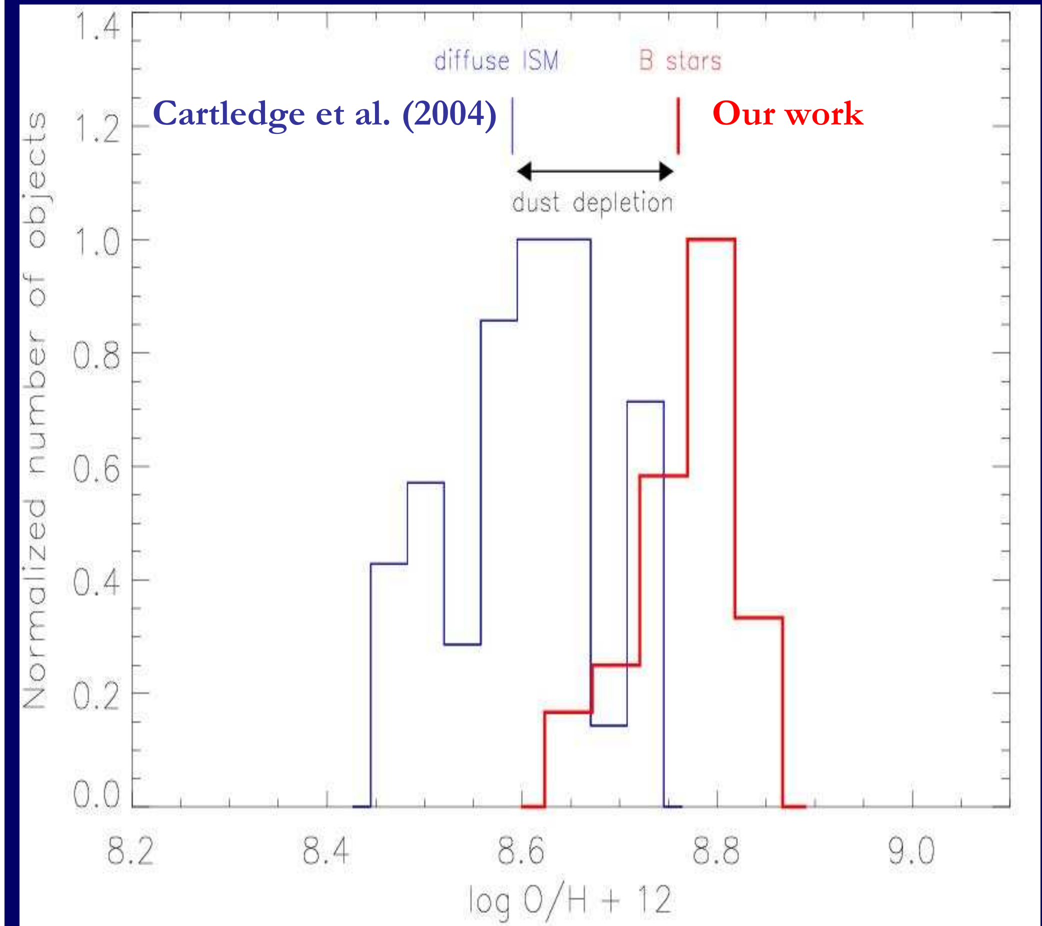
Mapping present-day oxygen in the solar neighborhood



Nieva & Przybilla 2012, A&A, 539, A143

Our oxygen abundances from B-stars vs. ISM: dust

Chemical homogeneity (~10%) ~ ISM



Nieva & Przybilla 2012, A&A, 539, A143

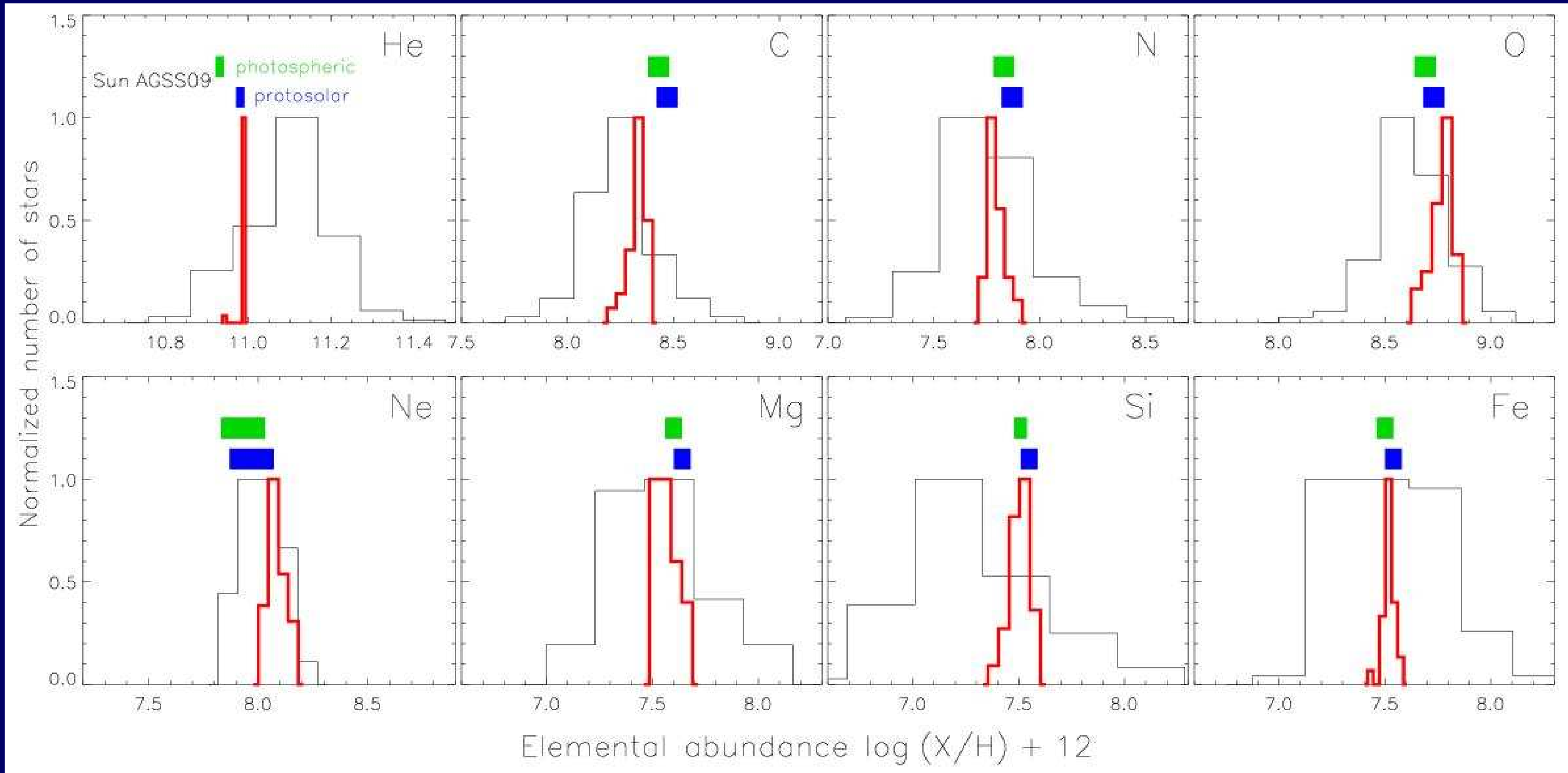
Dust composition in ppm:
(B-stars – ISM*/HII)**

	local ISM	Orion nebula
C	123 ± 23	~0
N	~0	…
O	168 ± 67	128 ± 73
Mg	35 ± 4	33 ± 4
Si	29 ± 4	28 ± 4
Fe	33 ± 2	32 ± 3

*Ref. ISM: Sofia et al. (2011), Meyer et al. (1997), Cartledge(2004,2006)

**HII Orion: Esteban et al. (2004), Simon-Diaz & Stasinska (2011)

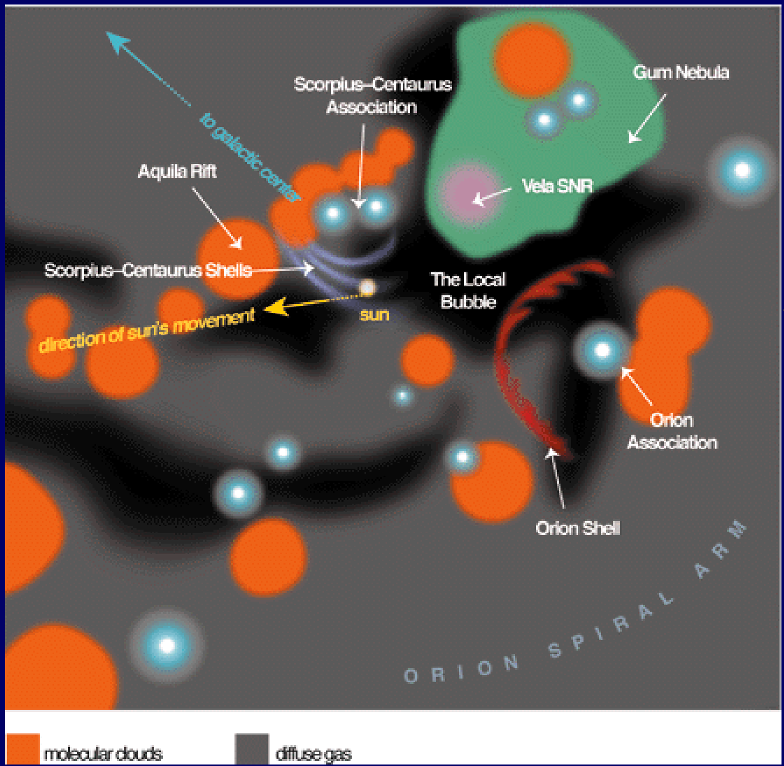
Present-day abundances in the solar neighbourhood



Nieva & Przybilla 2012, A&A, 539, A143

O and Si: same abundances from early B-type stars in Orion by Simon-Diaz (2010) (OII)

O and Mg: same abundances from BA-supergiants in the solar neighbourhood by Firnstein & Przybilla, subm. (OI)



Chemical homogeneity of ISM and stars:

consequence of turbulent mixing due to the large density variation of the gas

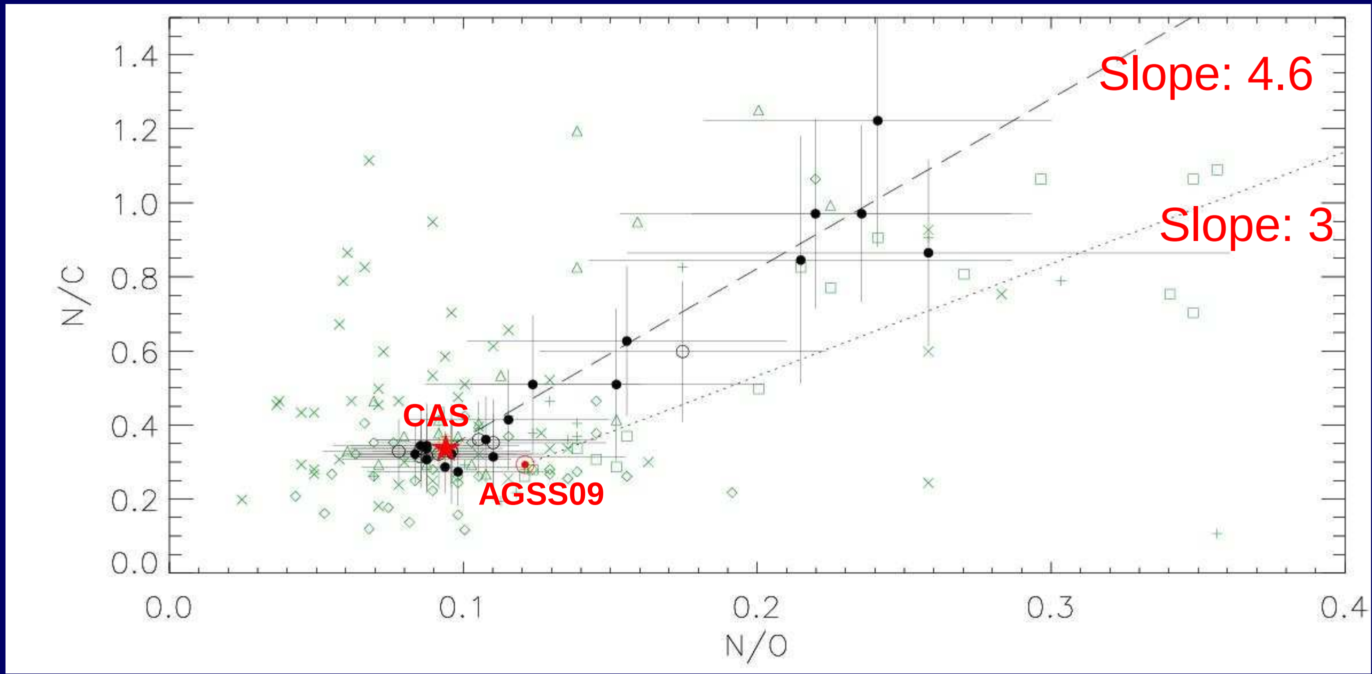
→ generated by complex interactions of momentum injection by stellar winds, supernova shocks, magnetic fields and self-gravity

Our results put constraints on:

injection and mixing timescales of metals in the local ISM

Critical test for stellar evolution

Observational constraints on the (magneto-)hydrodynamic mixing of CNO-burning products in massive stars



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In the Main Sequence, **the slope depends only on the initial abundance**, regardless on any other ingredient of the models (mass, rotational velocity, etc.)

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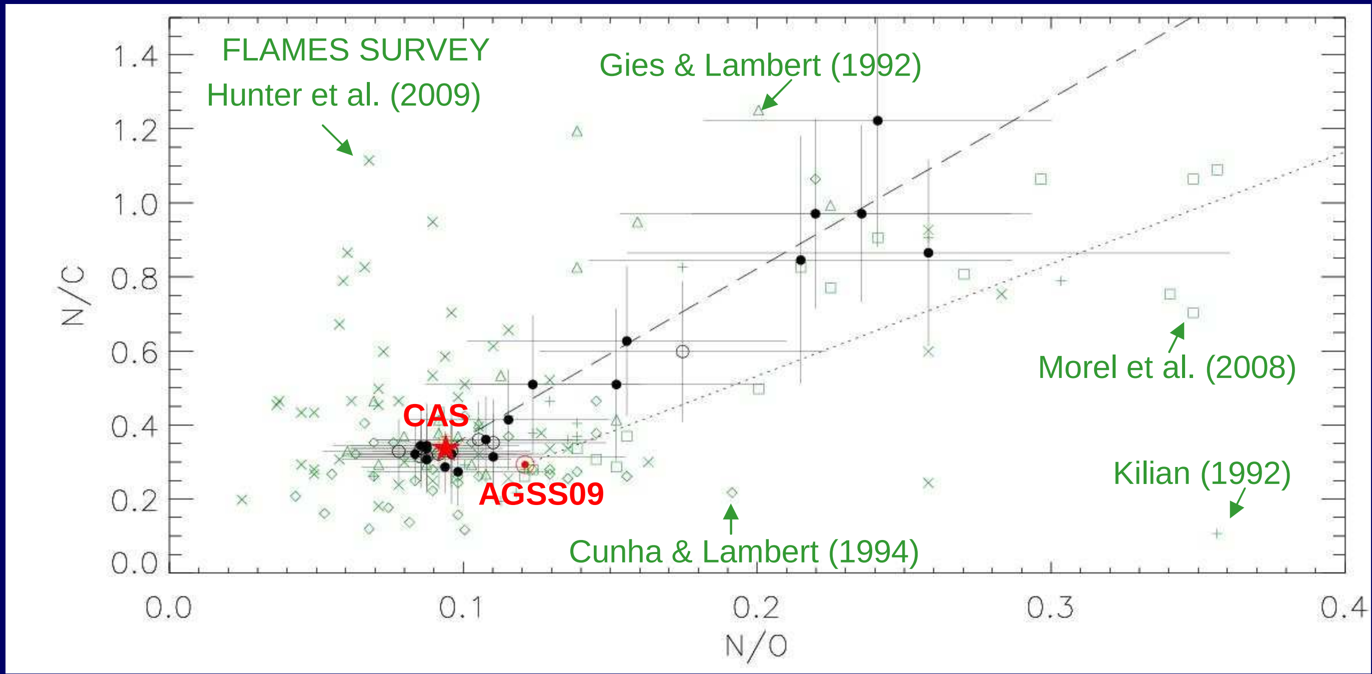

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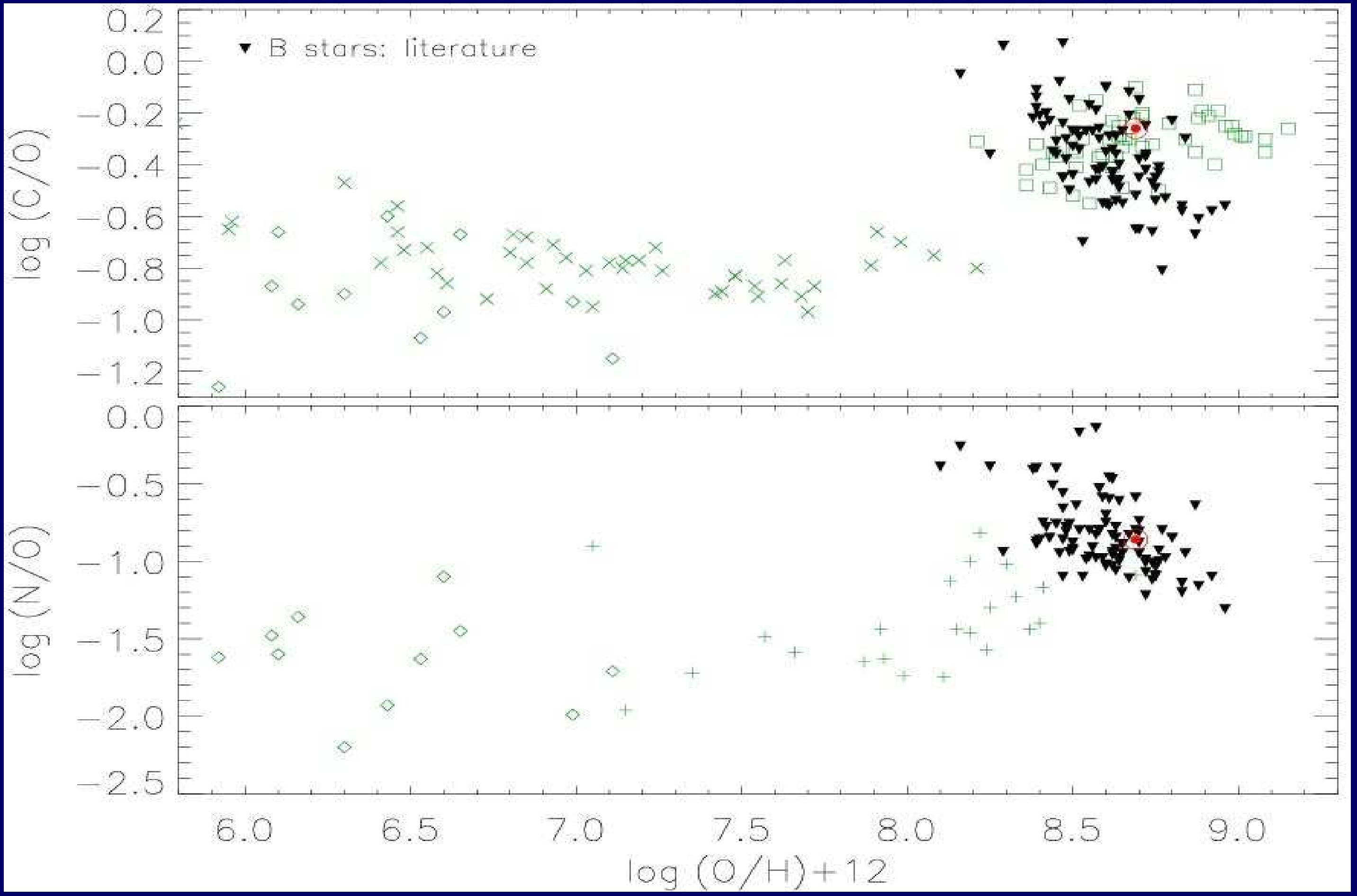
Galactic Chemical Evolution

OB stars: end point of GCE models



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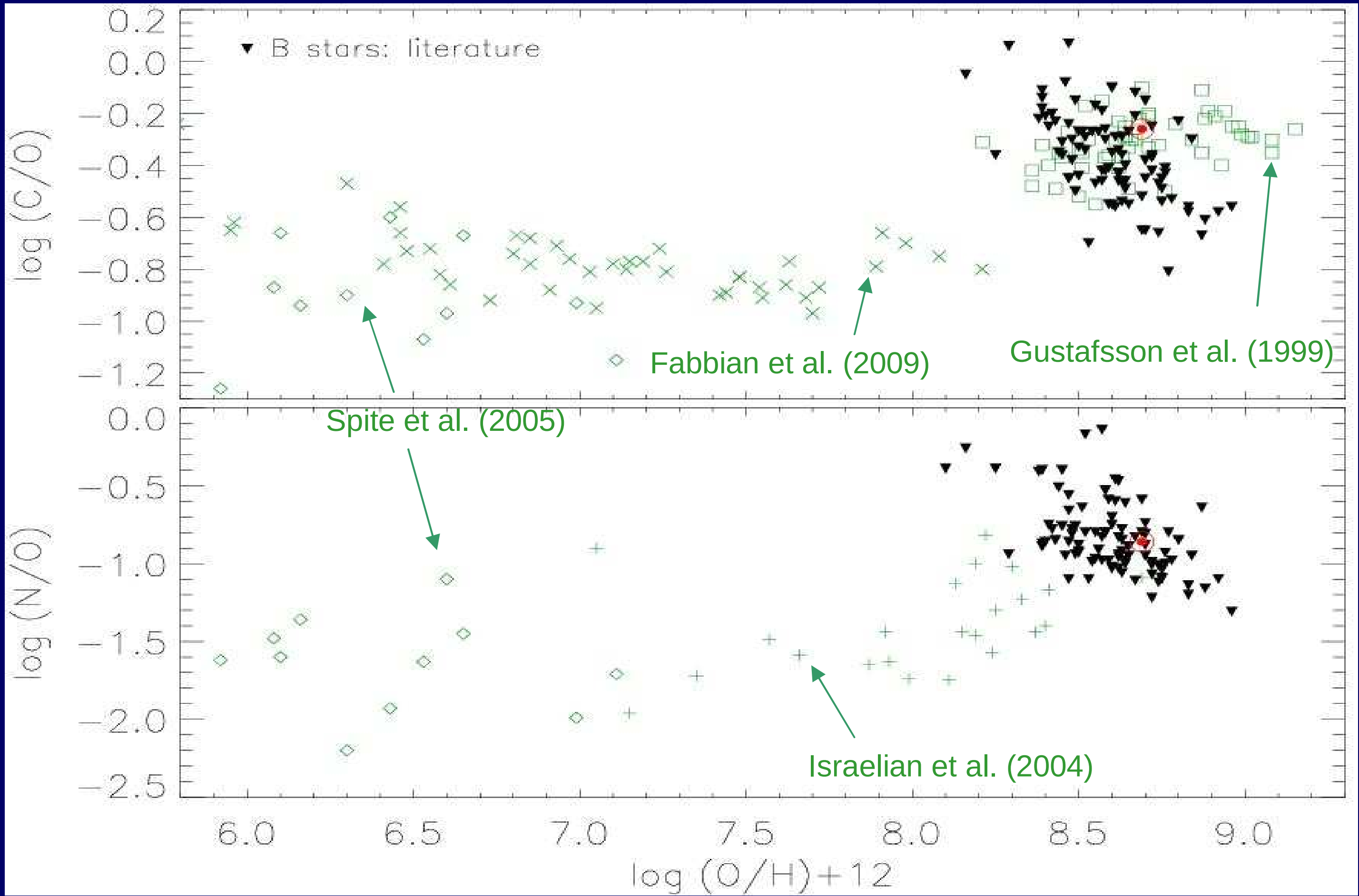

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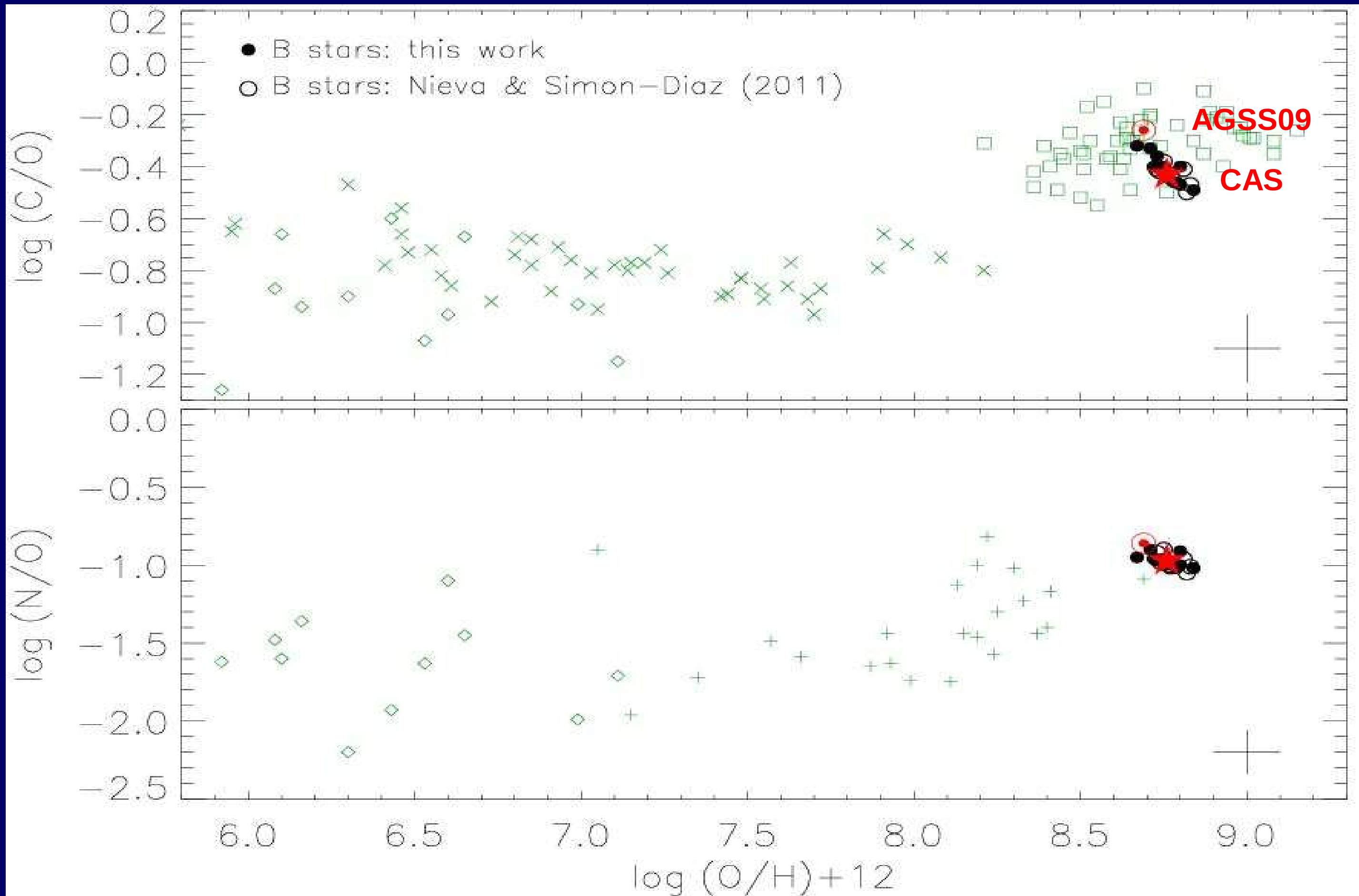

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OB (late O and early B)-type stars: reliable indicators for *present-day* and *birth-place* abundances

References: Nieva & Przybilla (2012) and series of previous work since 2006. Also Simon-Diaz (2010) + more in preparation.

Careful: most previous works on OB stars have several sources of systematics (e.g. parameters, NLTE effects, binarity)