Interstellar Constraints on the Cosmic Evolution of Lithium

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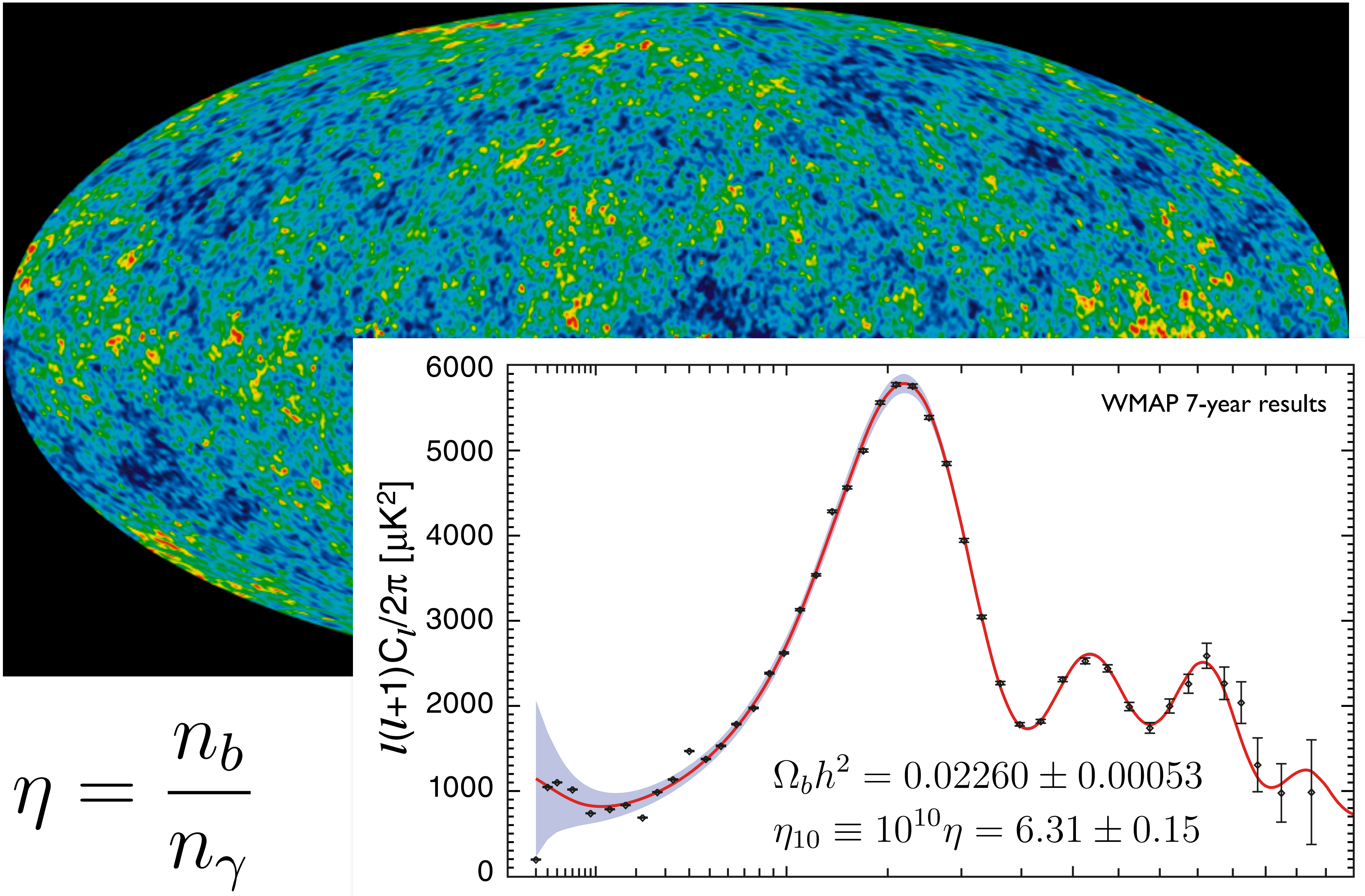
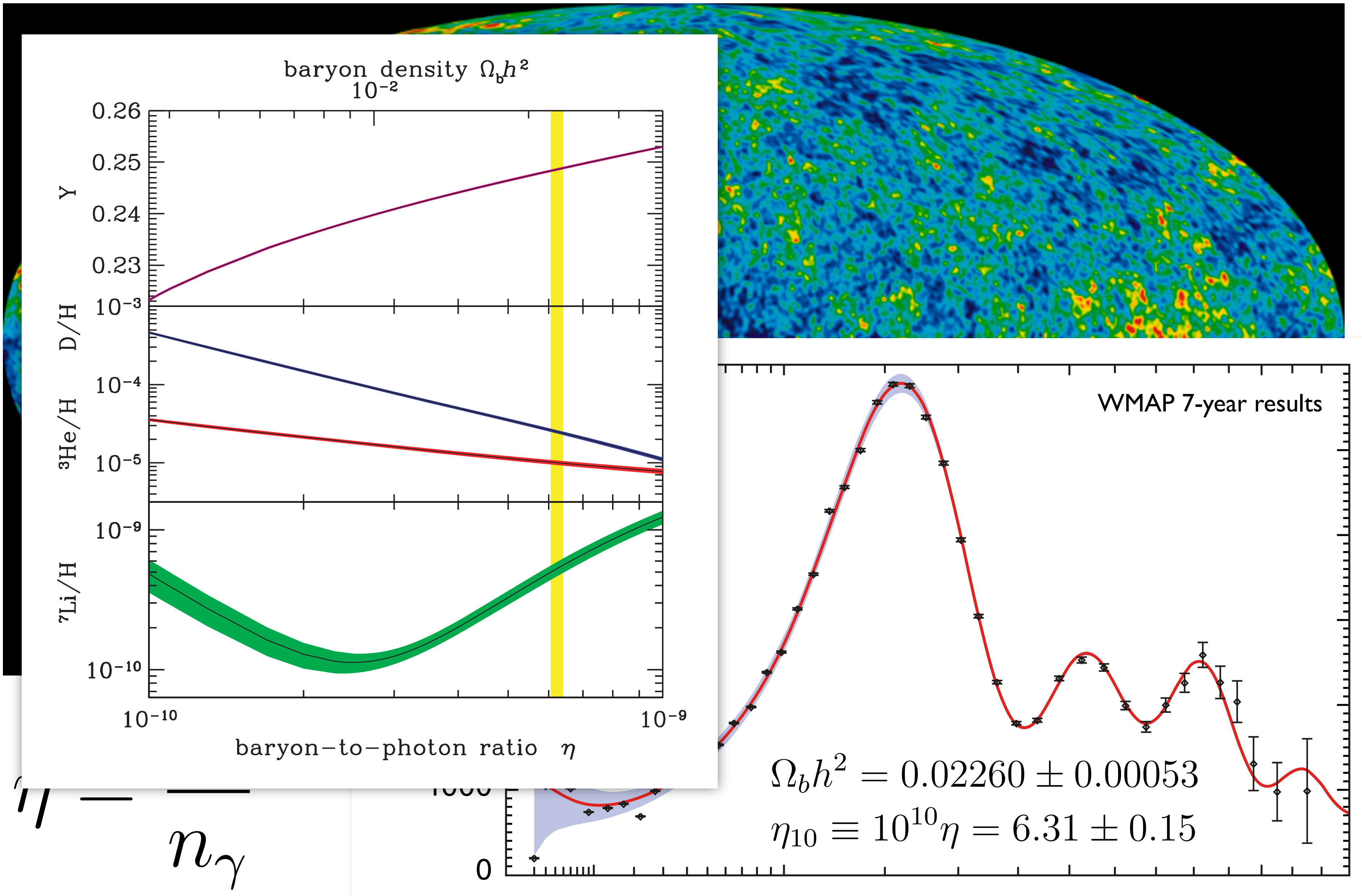
Big Bang Nucleosynthesis



Jarosik et al. (2010)

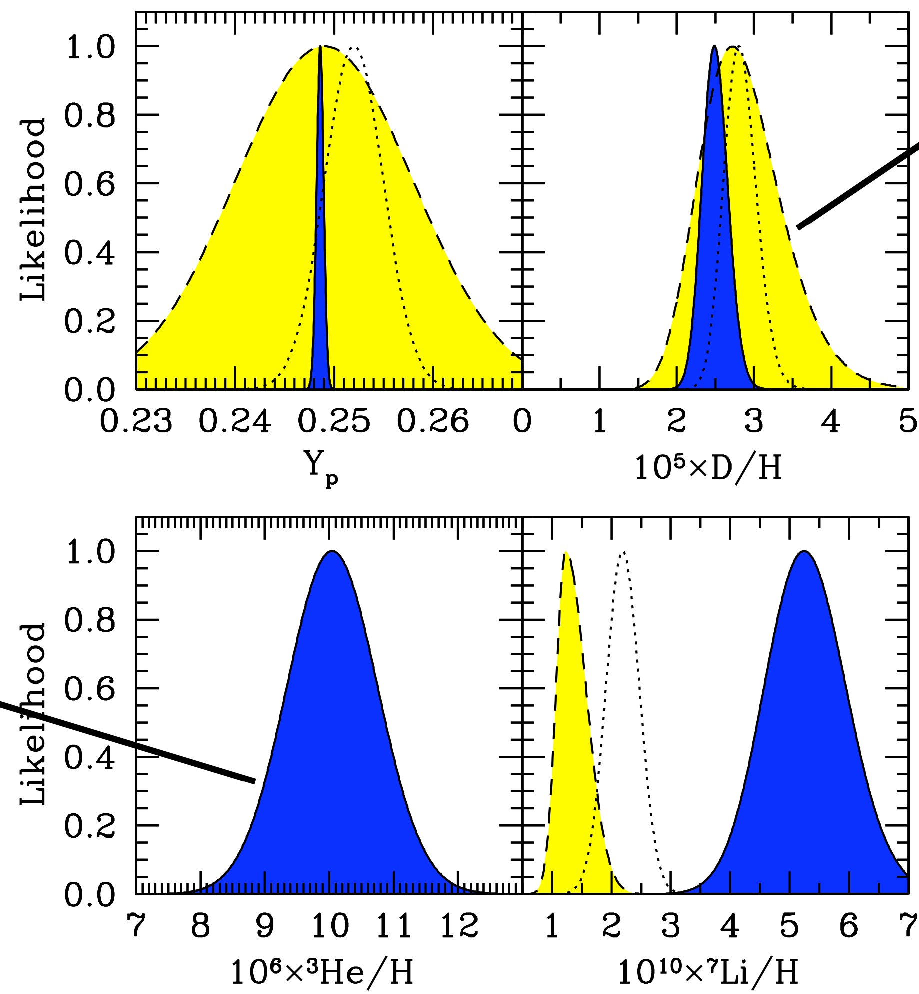
$$\eta = \frac{n_b}{n_\gamma}$$

Big Bang Nucleosynthesis



Jarosik et al. (2010)

The lithium problem: Pop II abundances inconsistent with SBBN



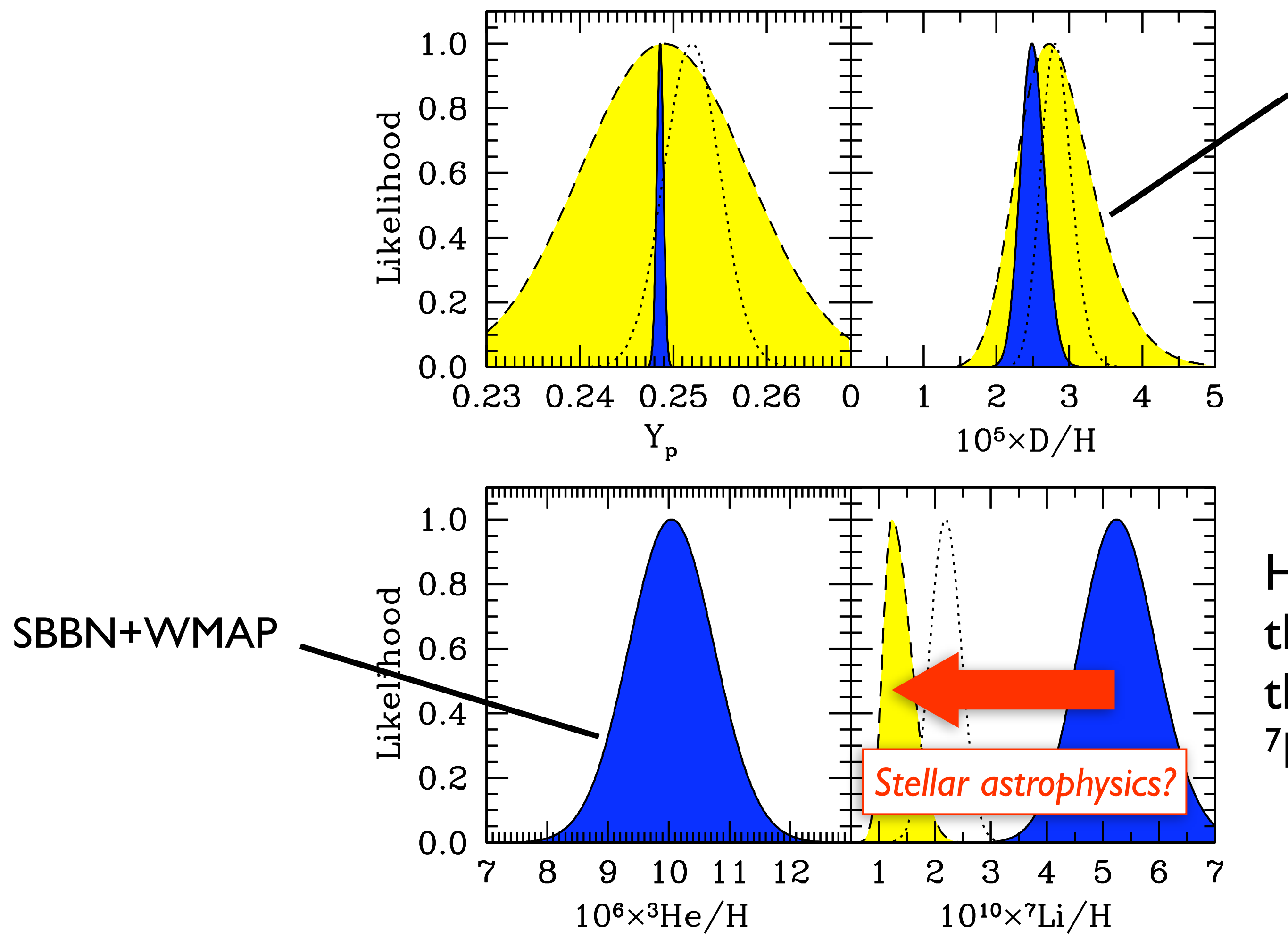
Observational Constraints

SBBN+WMAP

Hard to reconcile these estimates of the "primordial" ^{7}Li abundance.

Cyburt+ (2008)

The lithium problem: Pop II abundances inconsistent with SBBN



Cyburt+ (2008)

Hard to reconcile these estimates of the "primordial" ^7Li abundance.

E.g., destruction through Li(p,α)α or *gravitational settling.*

Non-Standard Model physics could explain the Li discrepancy

- **Decay** or **annihilation** of **dark matter** particles inject energetic Standard Model particles into BBN.
  - *Hadronic injection:* Decay products change n / p ratios or energetic decays spall ^{4}He particles.
  - *Electromagnetic injection:* Excess photons photodisentegrate D or α, providing excess ^{3}He/D.

$^3H+^4He \rightarrow ^6Li+n$	$^3He+^4He \rightarrow ^6Li+p$	Enhance ^{6}Li
$n+^7Be \rightarrow ^7Li+p$	$^7Li+p \rightarrow ^4He+^4He$	Suppress ^{7}Li

- Charged dark matter particles **catalyze** BBN
  - *Negatively charged particles (X-) create bound particles with baryonic nuclei, reducing Coulombic barriers.*

Suppresses ^{7}Be (and thus ^{7}Li) and/or enhances ^{6}Li.

(see Jedamzik & Pospelov 2009)

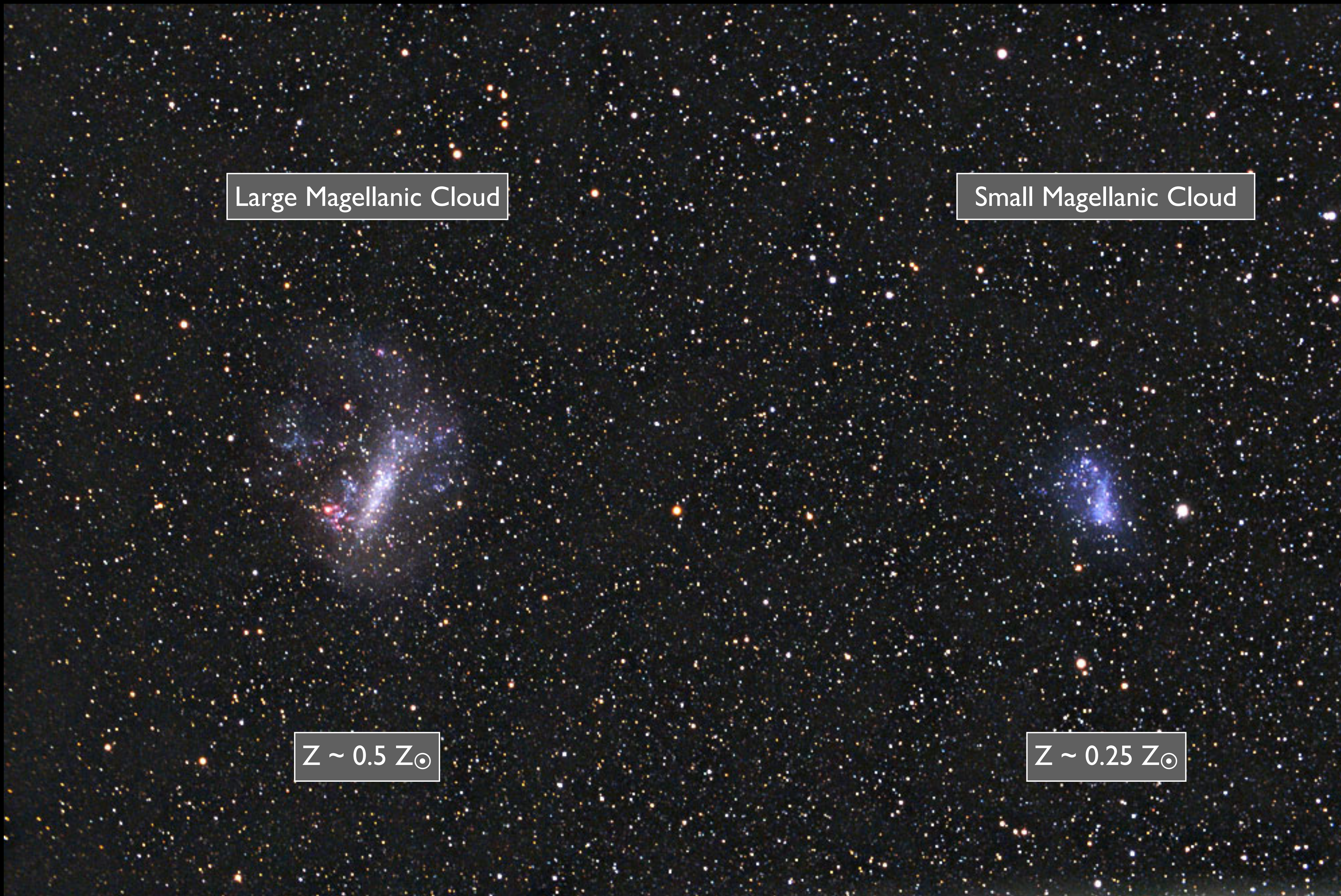
Interstellar Li as a probe of pre-galactic production

The idea:

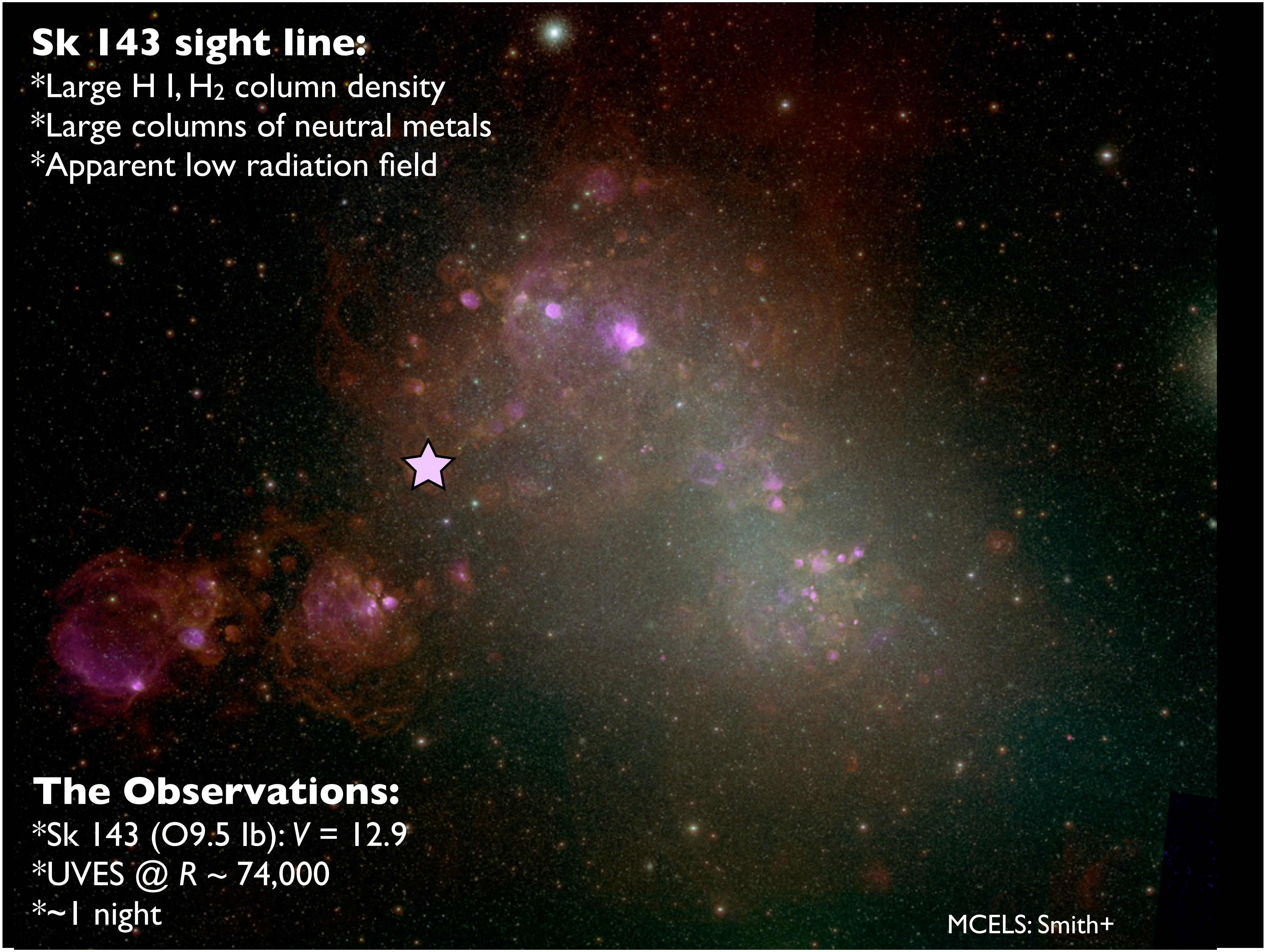
Use ***interstellar*** Li in low metallicity environments as a probe of the contemporary Li abundance.

While the chemical evolution of Li is complex, there is no worry about time-dependent *in situ* destruction modifying the abundance of Li over time.

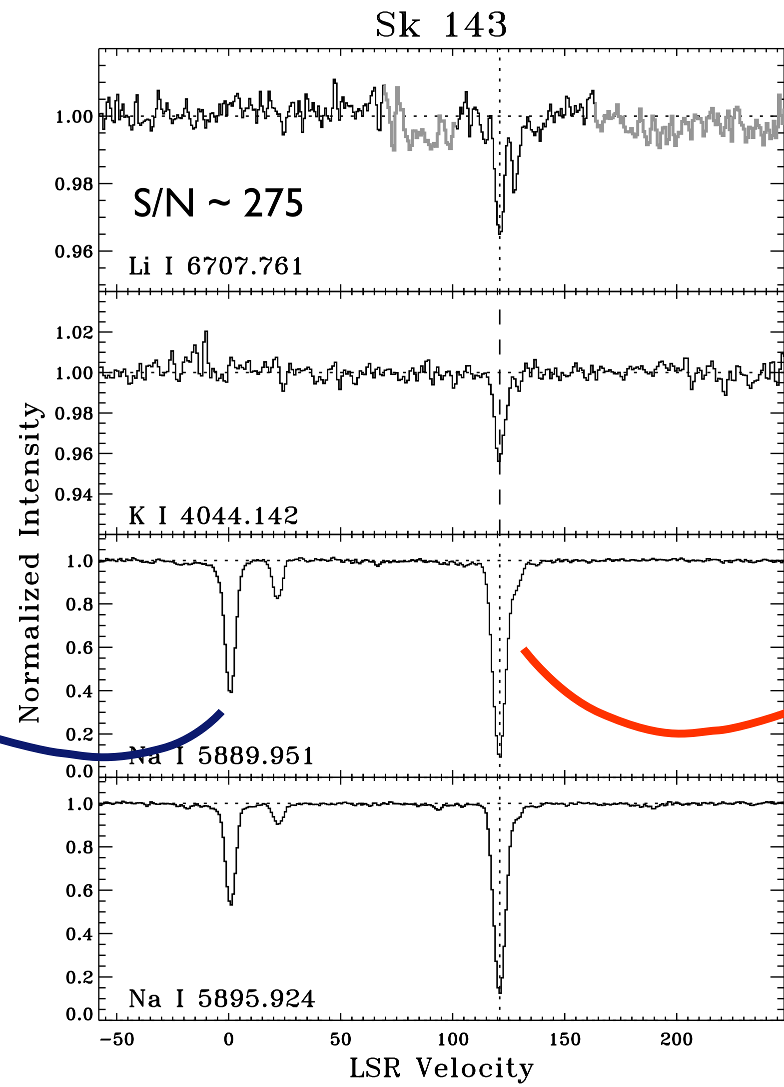
Significant uncertainties in the approach are ***completely independent*** of those affecting stellar measurements.



**This was attempted toward SN1987A using ESO telescopes (Vidal-Madjar et al. 1987; Sahu et al. 1988).*


Sk 143 sight line:
*Large H I, H2 column density
*Large columns of neutral metals
*Apparent low radiation field
The Observations:
*Sk 143 (O9.5 Ib): V = 12.9
*UVES @ R ~ 74,000
*~1 night
MCELS: Smith+

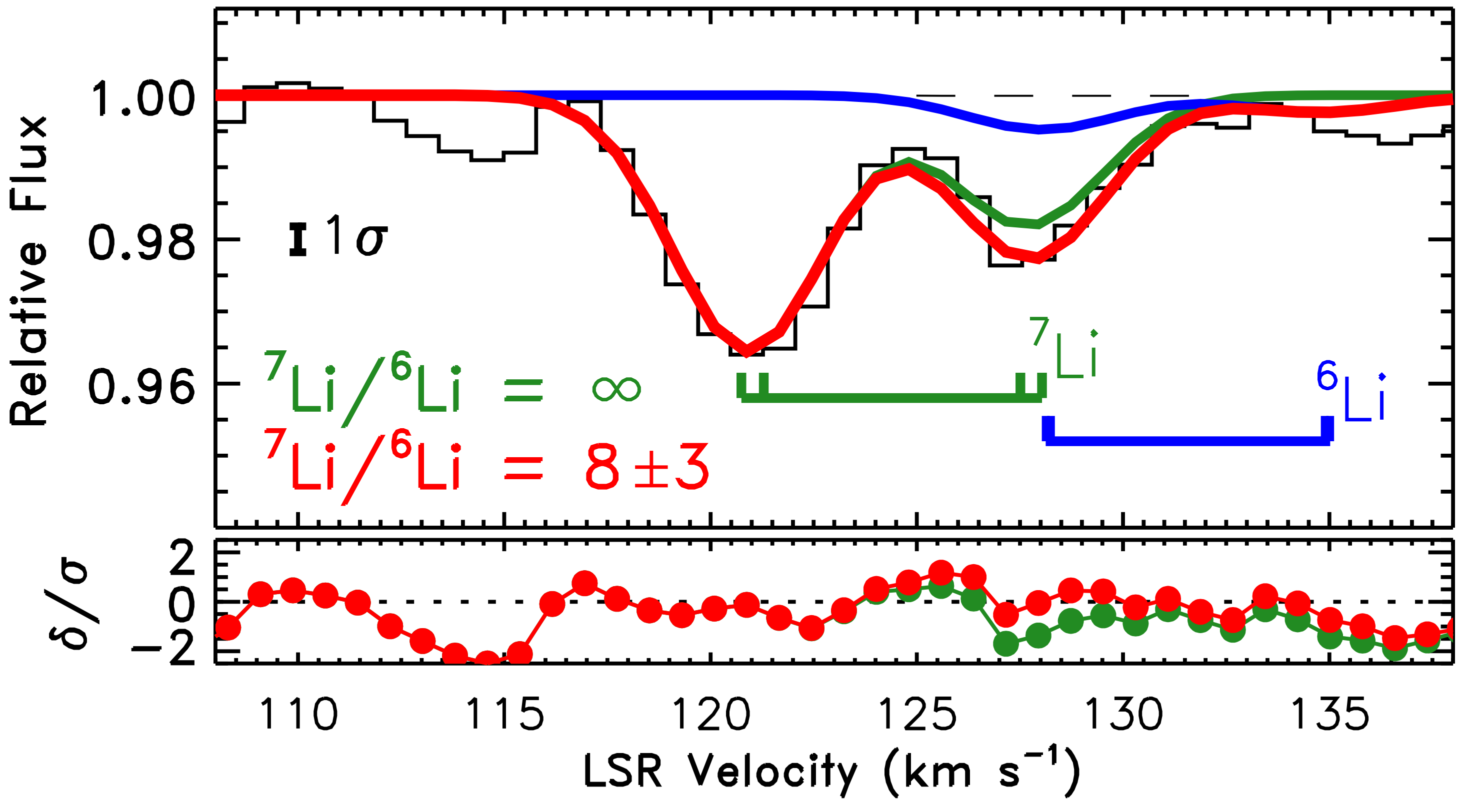
Interstellar Li as a probe of pre-galactic production



Absorption from the MW at v ~ +0 to +50 km/s

Absorption from the SMC at v ~ +120 km/s

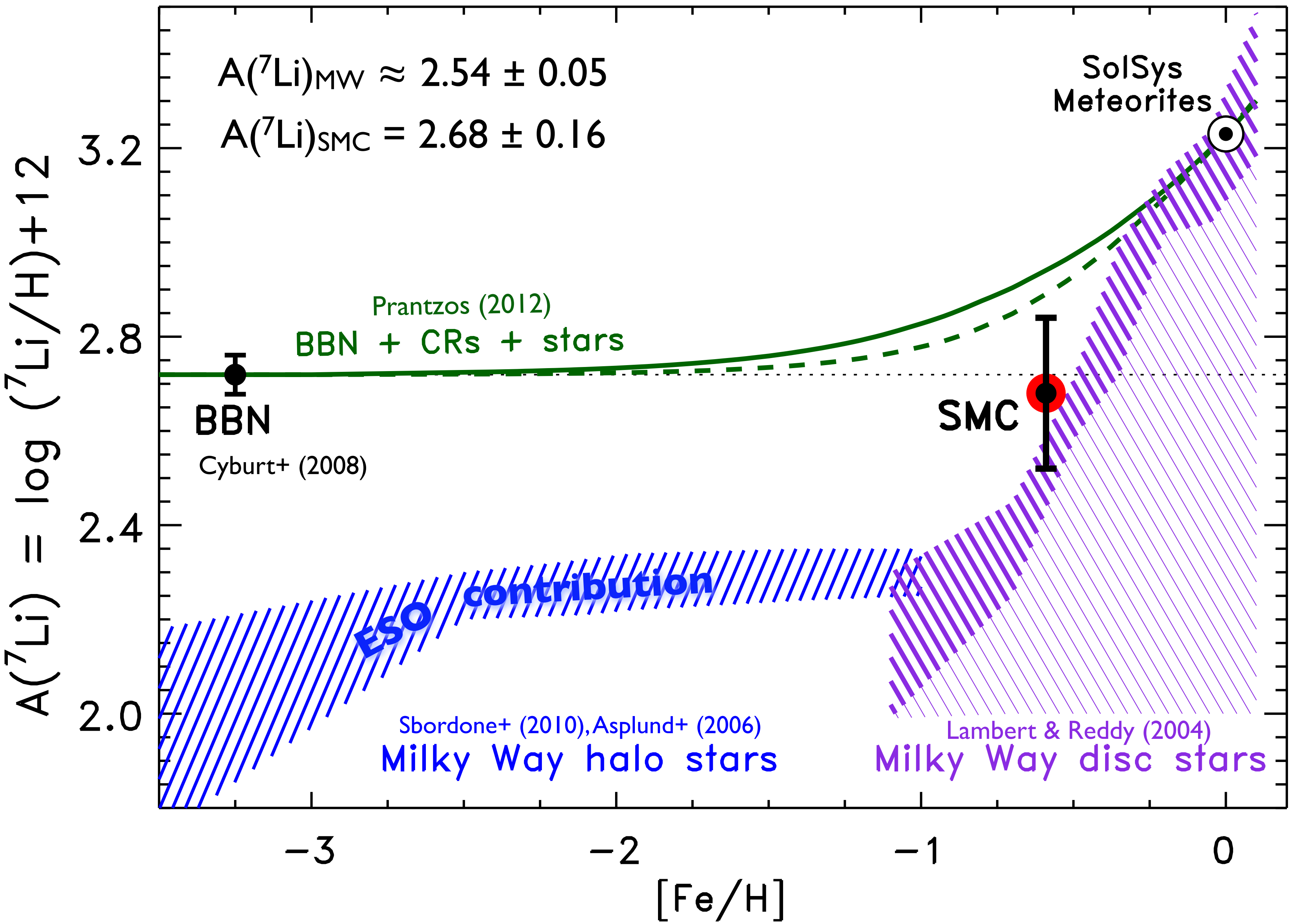
Interstellar Li as a probe of pre-galactic production



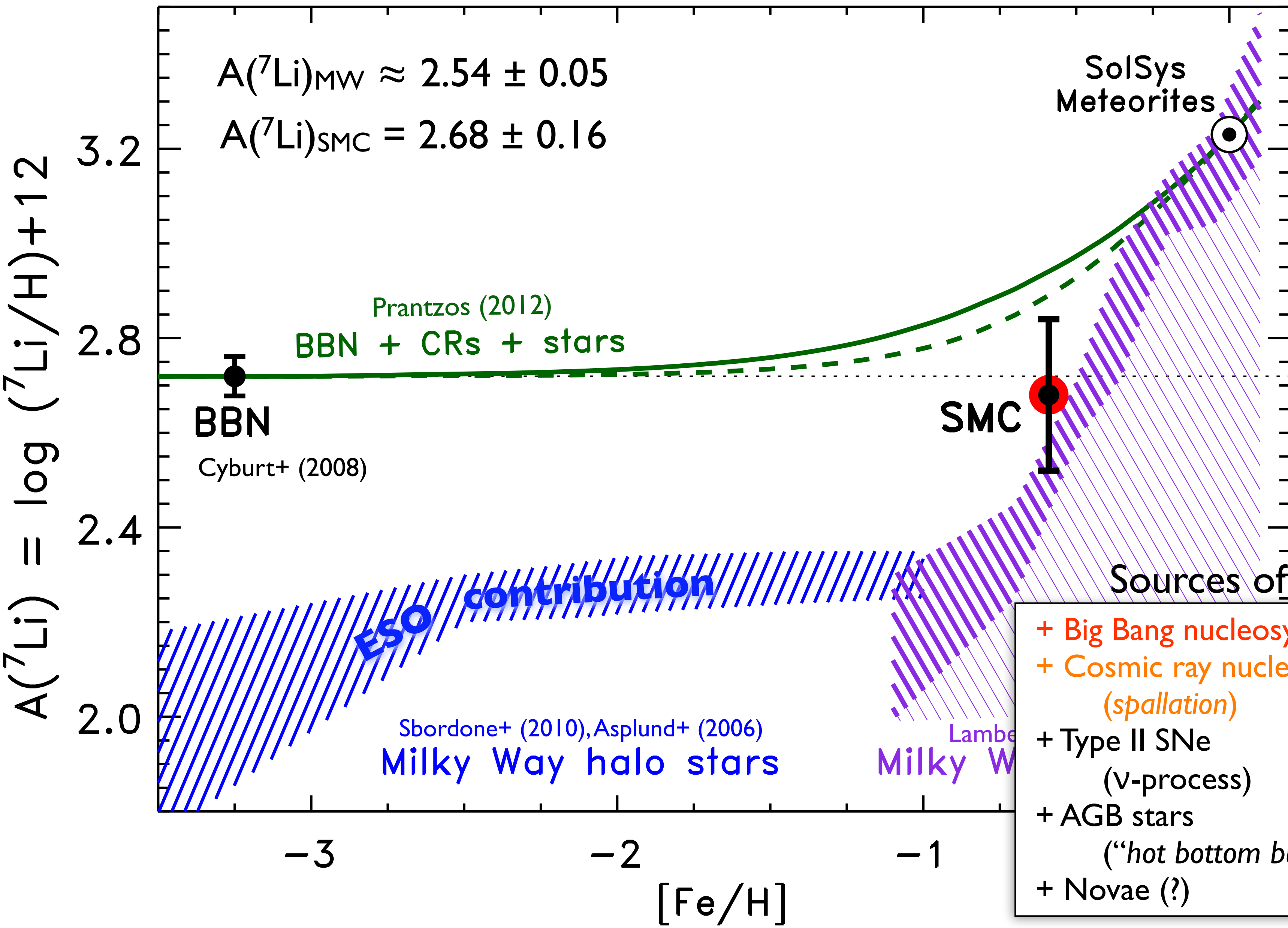
$b \equiv 2^{1/2}\,\sigma \sim 0.8$ km/s

$T \lesssim 270$ K

Interstellar Li as a probe of pre-galactic production



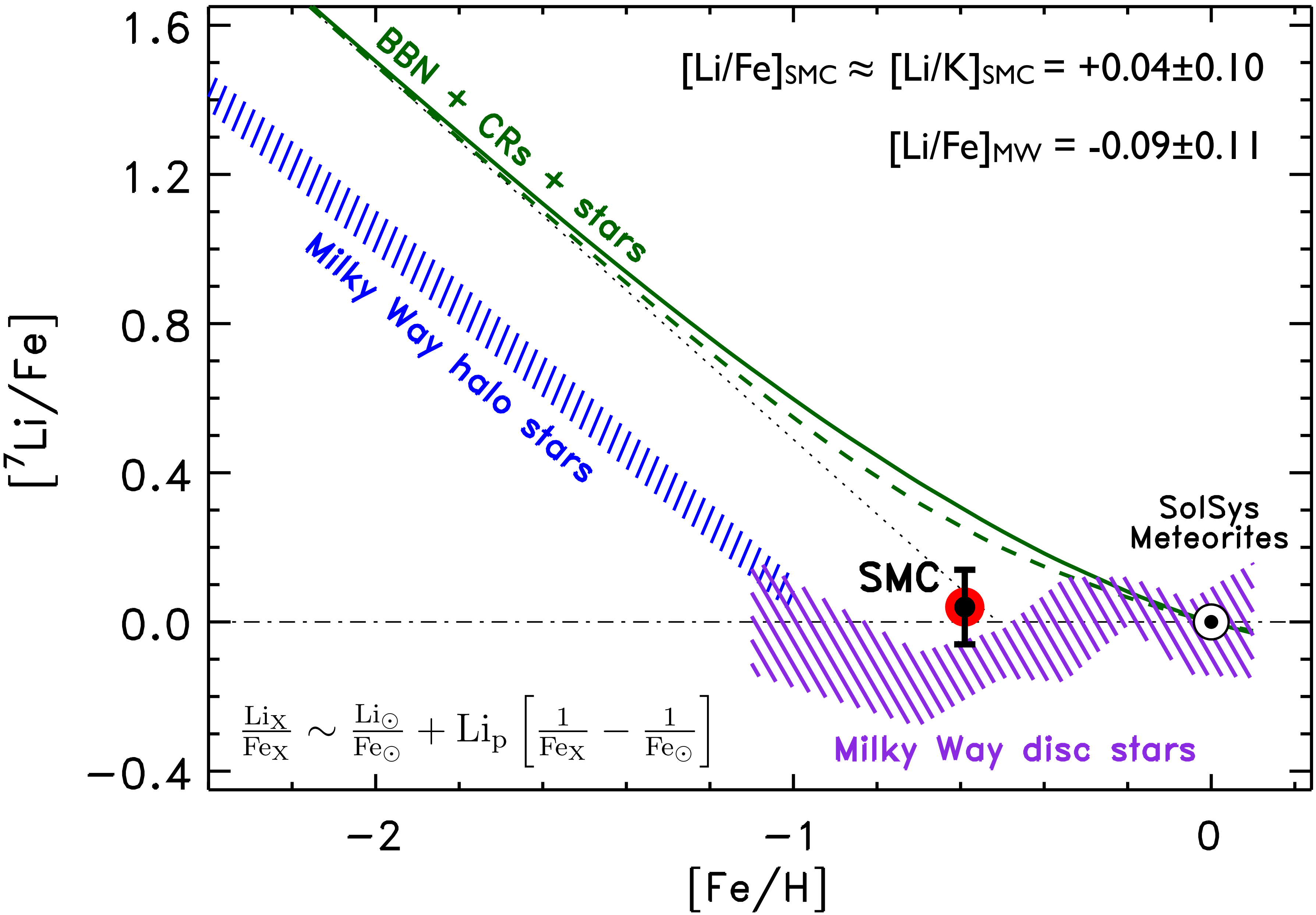
Interstellar Li as a probe of pre-galactic production



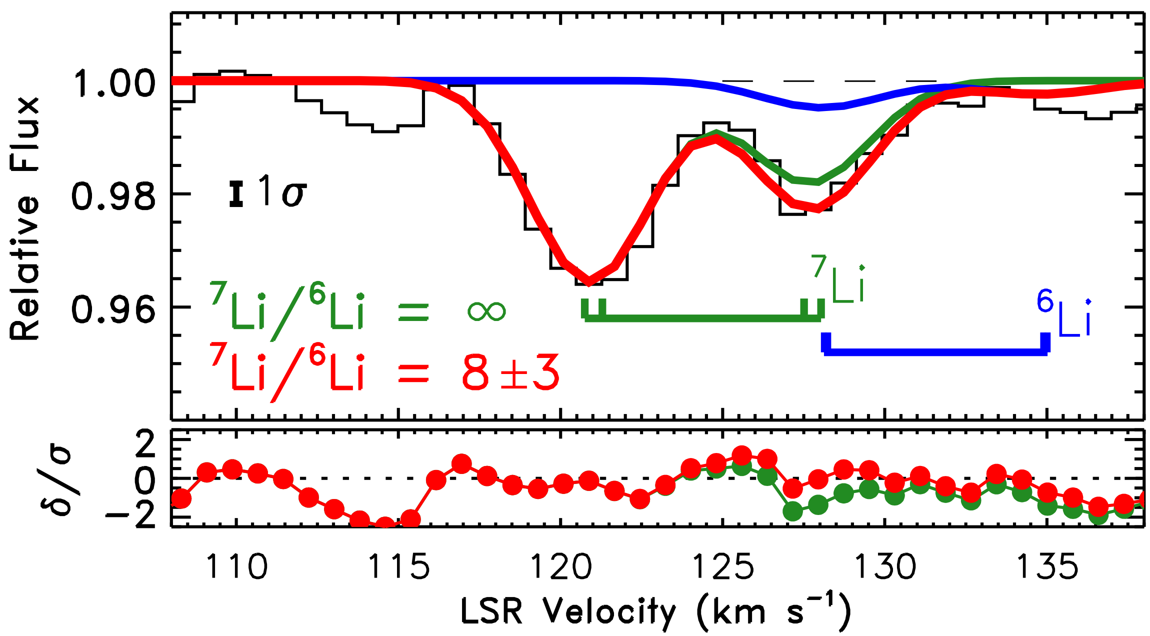
Sources of ^{7}Li:

+ Big Bang nucleosynthesis
+ Cosmic ray nucleosynthesis (*spallation*)
+ Type II SNe (ν-process)
+ AGB stars ("*hot bottom burning*")
+ Novae (?)

Interstellar Li as a probe of pre-galactic production



Interstellar Li as a probe of pre-galactic production



Standard BBN and chemical evolution predict the SMC should have

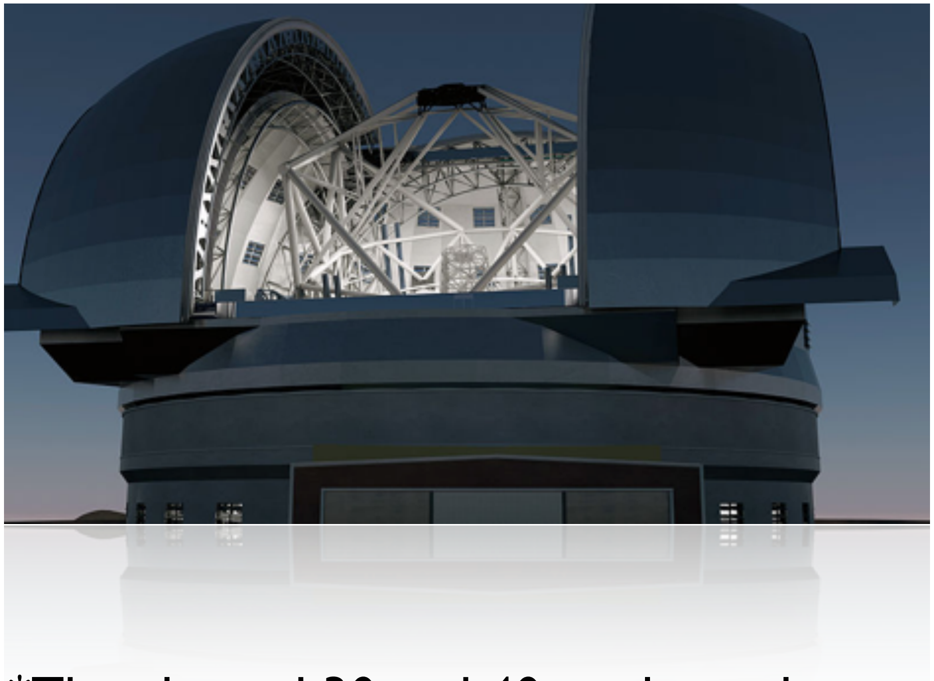
$$^{6}Li/^{7}Li \sim 0.01\text{–}0.02$$

Non-standard models predict

$$^{6}Li/^{7}Li \sim 0.05 – 0.10.$$

At S/N ~ 500, we should detect ^{6}Li in the SMC in the latter case.

Interstellar Li in the ELT era



With 10-m class telescopes, this approach is limited to the SMC, LMC, and a single low-redshift damped Lyman-α (DLA) absorber *with LMC-like metallicity*.

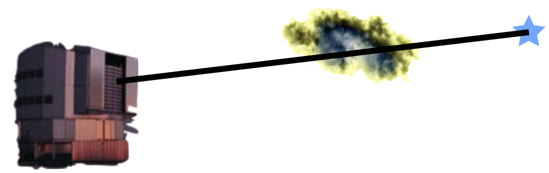
*The planned 30 and 40-m class telescopes have the *grasp* to extend the search for interstellar Li to more **DLAs**. However, there are several issues:

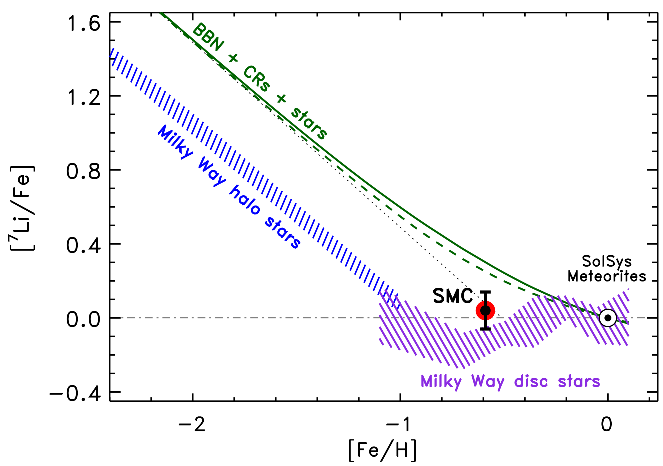
1) Li will be redshifted quickly into the NIR.
2) The number of bright QSOs with quite low metal DLAs is limited.
3) The number of DLAs bearing neutral gas and/or H_2 is *VERY* limited.

*Studies of the SMC/LMC isotopic ratio and its variations should be straightforward.

Summary

- Measurements of interstellar Li I in low metallicity galaxies will allow us to probe primordial and pre-galactic production of Li (including the $^{7}Li/^{6}Li$ ratio) in a way that is ***independent of the systematics associated with stellar determinations***.





- The first measurement of gas-phase Li in the SMC suggests a current abundance consistent with the BBN value, leaving little room for chemical enrichment. ***This may favor a low primordial abundance.***

- The first marginal measurement of the isotopic ratio in the SMC implies that <40% of the ^{7}Li had been produced since the era of Big Bang nucleosynthesis. ***The $^{6}Li/^{7}Li$ ratio may represent the best test on non-standard BBN from the ISM.***