Discovery of 13 Lithium-rich Red Giants in Milky Way Dwarf Satellite Galaxies

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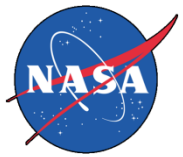
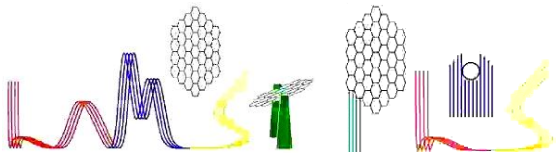




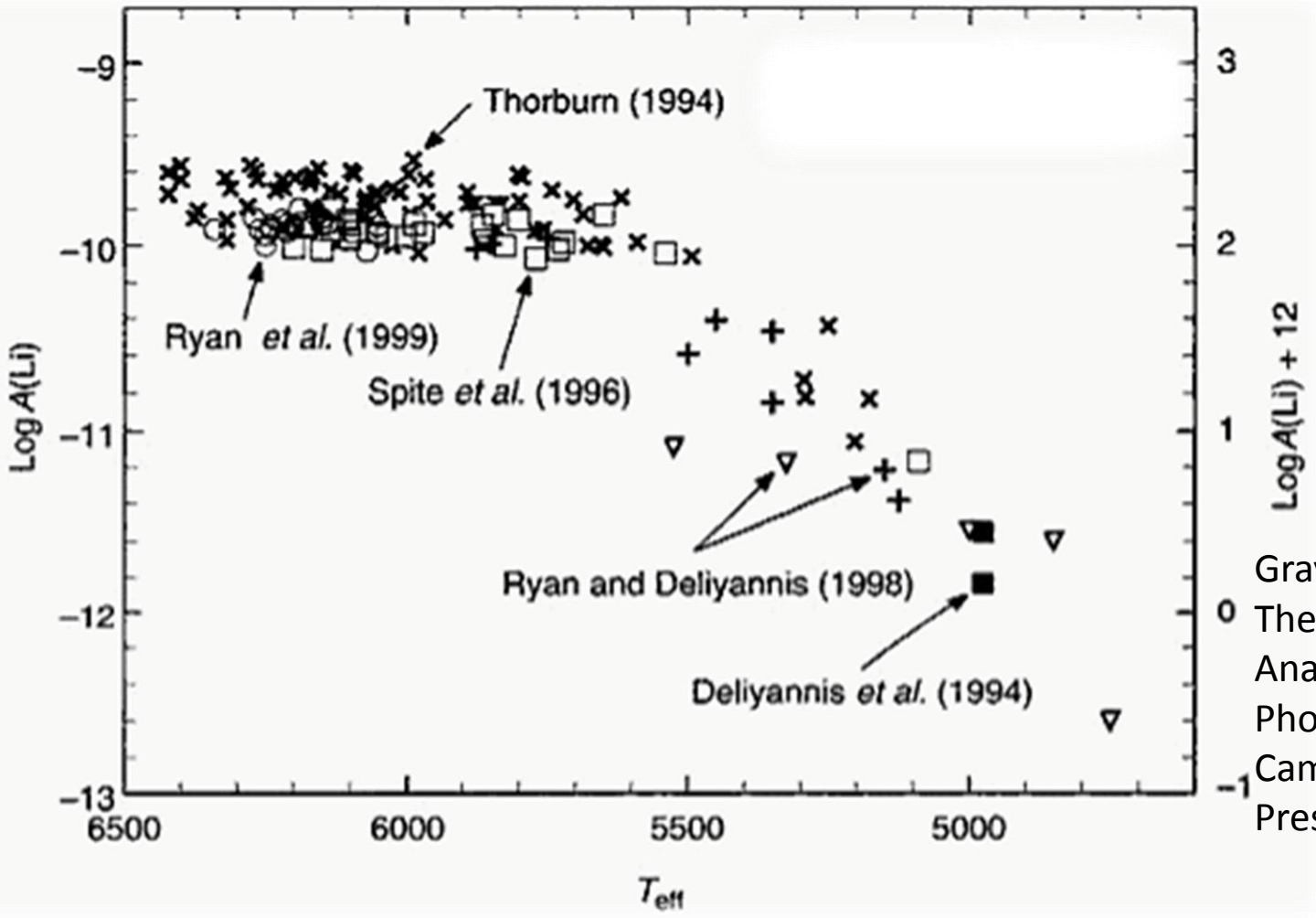
Lithium in the cosmos, Feb,28, IAP

WHY Lithium Giants are unusual?

- Lithium is easily destroyed in the stellar interiors at temperatures higher than $\sim 2.5 \times 10^6$ K (7Li)
  $\sim 2.0 \times 10^6$ K (6Li)

WHY Lithium Giants are unusual?

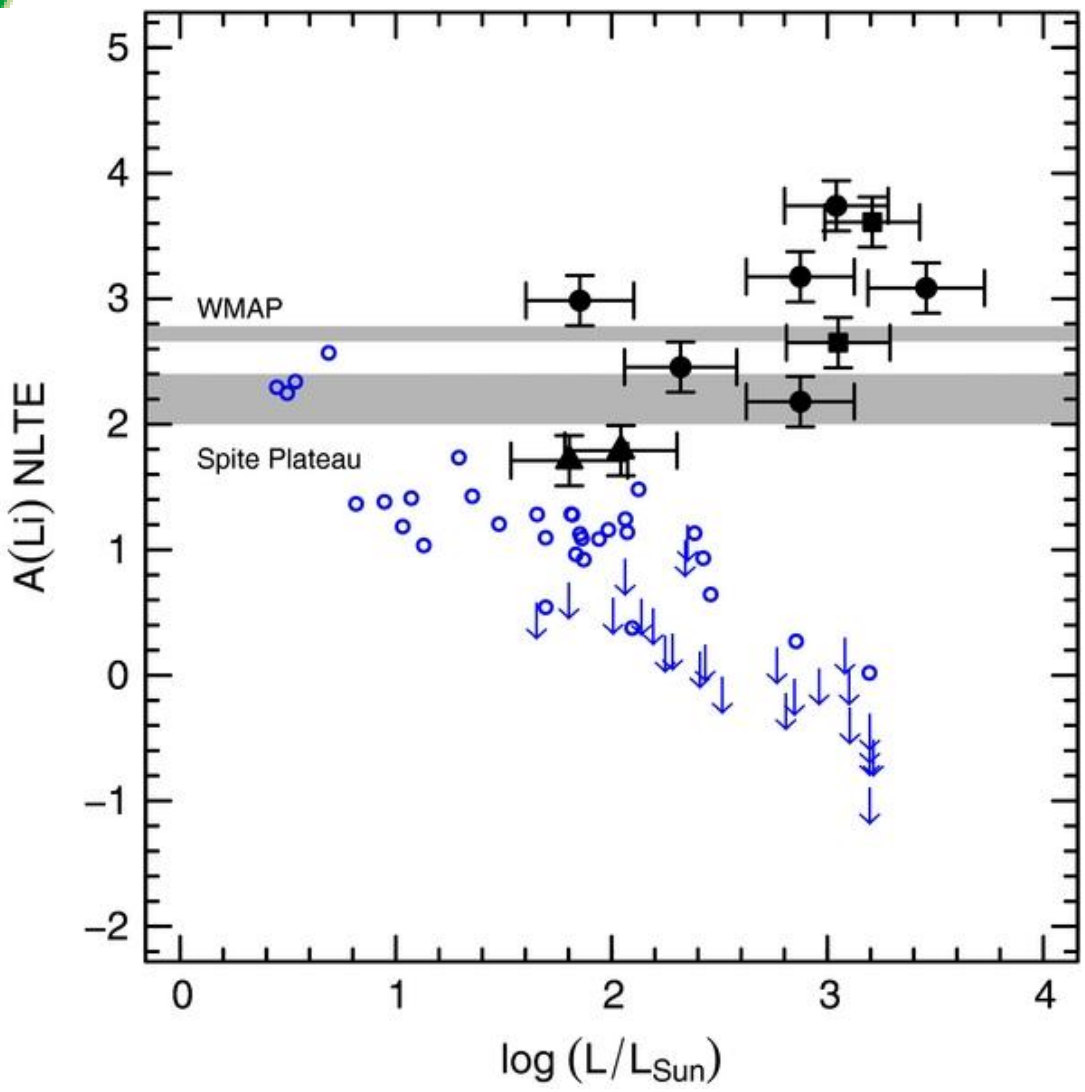
$$* A(Li) = \log \frac{n(Li)}{n(H)} + 12$$



Gray, David. The Observation and Analysis of Stellar Photospheres, Cambridge University Press, 2005

A(Li) <0.5 is typical for stars on the upper red giant branch(RGB) (Lind et al. 2009).

Former discoveries

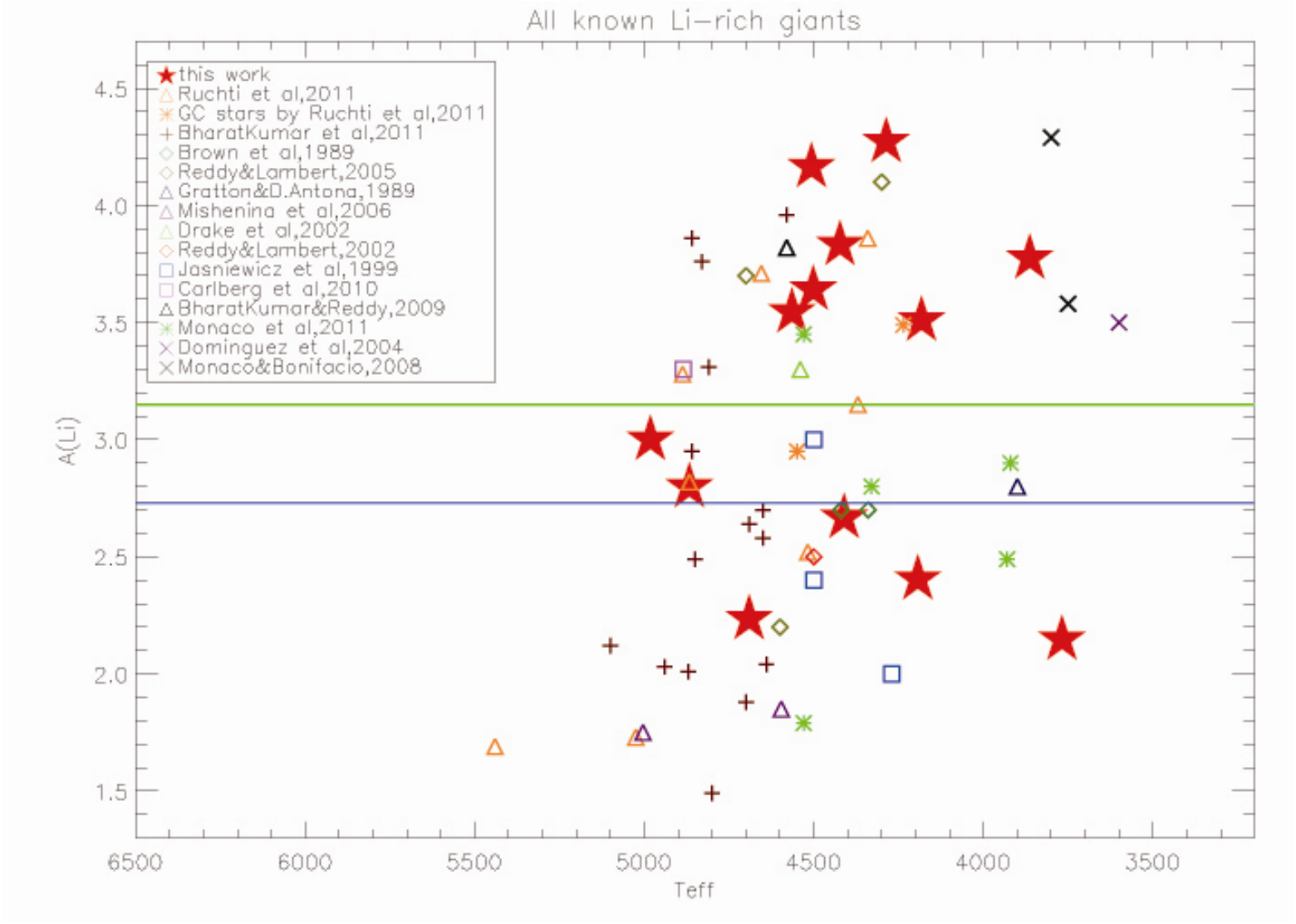


Ruchti et al 2011. APJ, 743. 107

For field stars, this phenomenon seems to happen in about 1% of metal-poor red giants

- Brown et al. 1989, ApJS, 71, 293
- Pilachowski et al. 2000, AJ, 119, 2895
- Monaco et al. 2011, A&A,529,A90

Former discoveries



43 field stars, 2 GC stars, 3 dSph stars

Former discoveries

This is the third time.

Before our work,

people only know 3 Lithium Giants

in the Milky Way dwarf galaxies,

Now, we have **13** more.

Data

The measurements are based on:

KECK */DEIMOS medium-resolution spectroscopy (MRS)*

R=6500

dSph	Date
Sculptor	2008 Aug 3 , Aug4 , Aug 31, Sep 1, Sep 1
Fornax	2008 Sep 1 , Nov 25, Nov 26, Aug 31, Sep 30
Leo I	2003 Oct 29, 2003 Oct 15, 2006 Feb 2,Feb 3,Feb 4
Sextans	2009 Feb 22, Feb 23
Leo II	2006 Feb 2, Feb 3, Feb 4
Canes Venatici I	2007 Feb 14, Feb 15
Ursa Minor	2009 Feb 22, Feb 23
Draco	2009 May 23, May 24

Kirby et al. 2010, ApJS 191,352

Data

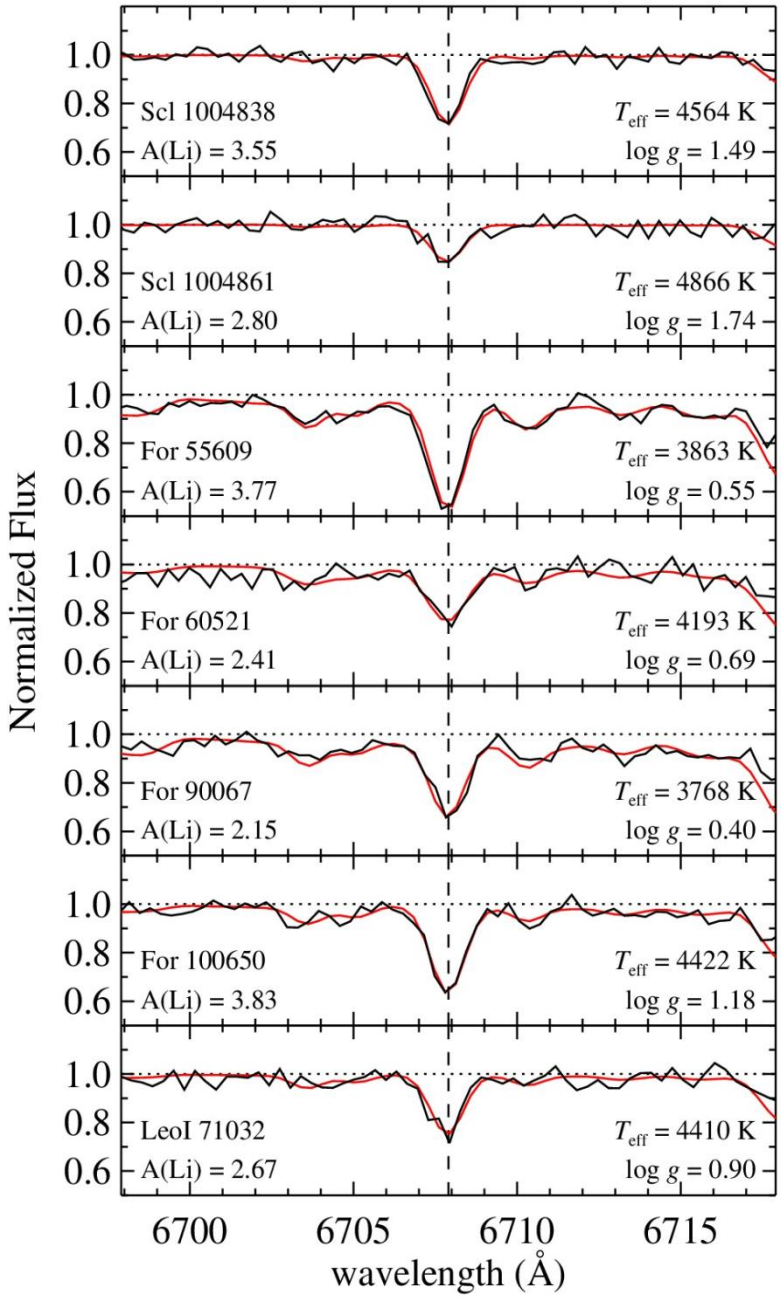
Target:

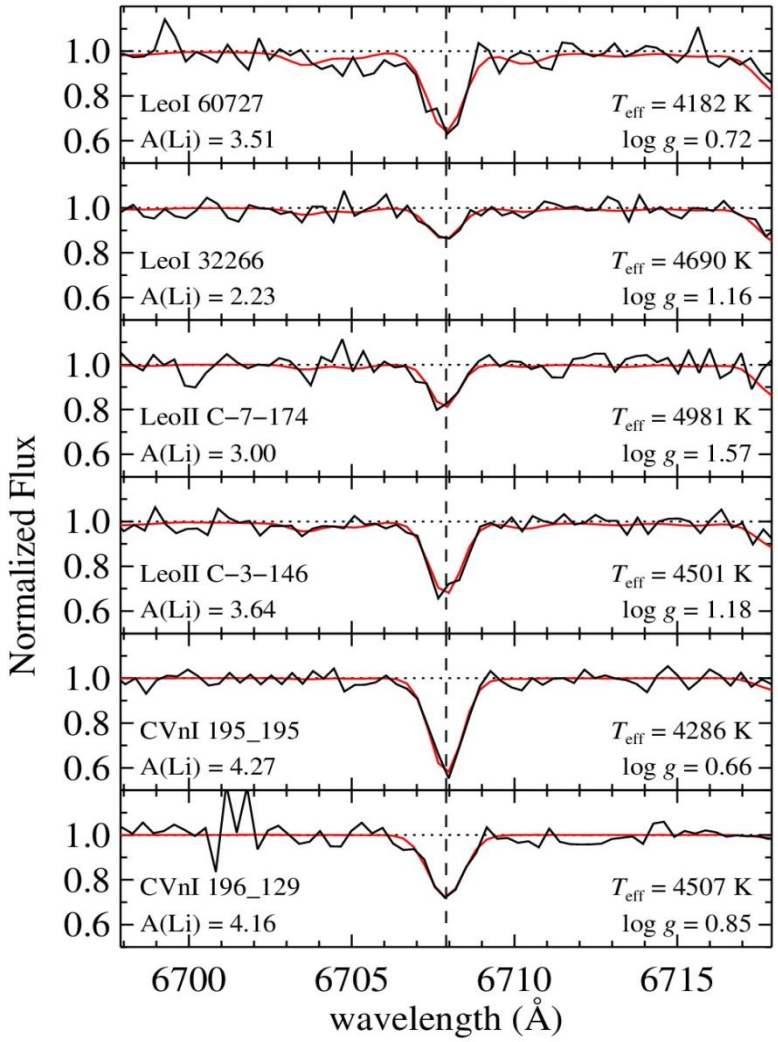
4880 stars in eight dwarf satellite galaxies of the Milky Way (MW):

Sculptor, Fornax, Leo I, Sextans, Leo II, Canes Venatici I, Ursa Minor, and Draco.

Distance: 85 – 220 kpc

Lithium doublet
at 6707.761 and 6707.912 Å



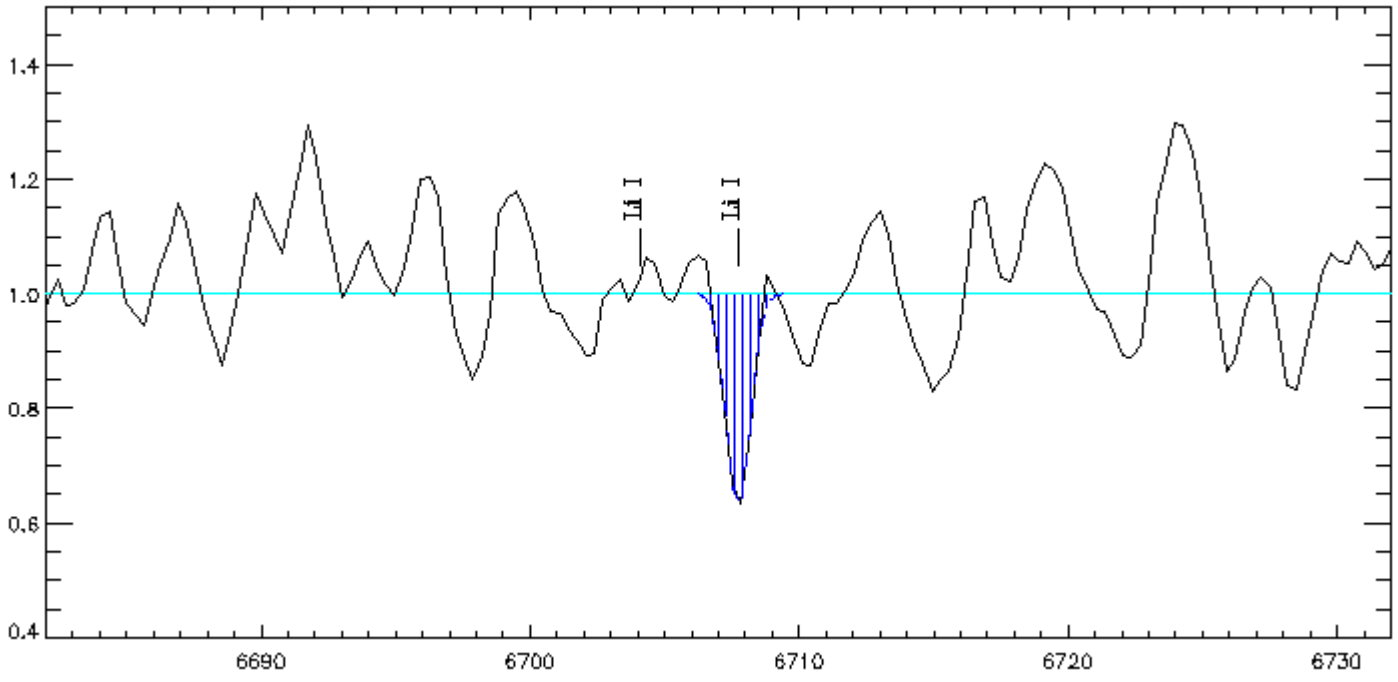


Kirby, Fu & Guhathakurta, Deng,
to be submitted to ApJ

Confirm a Carbon star with Lithium

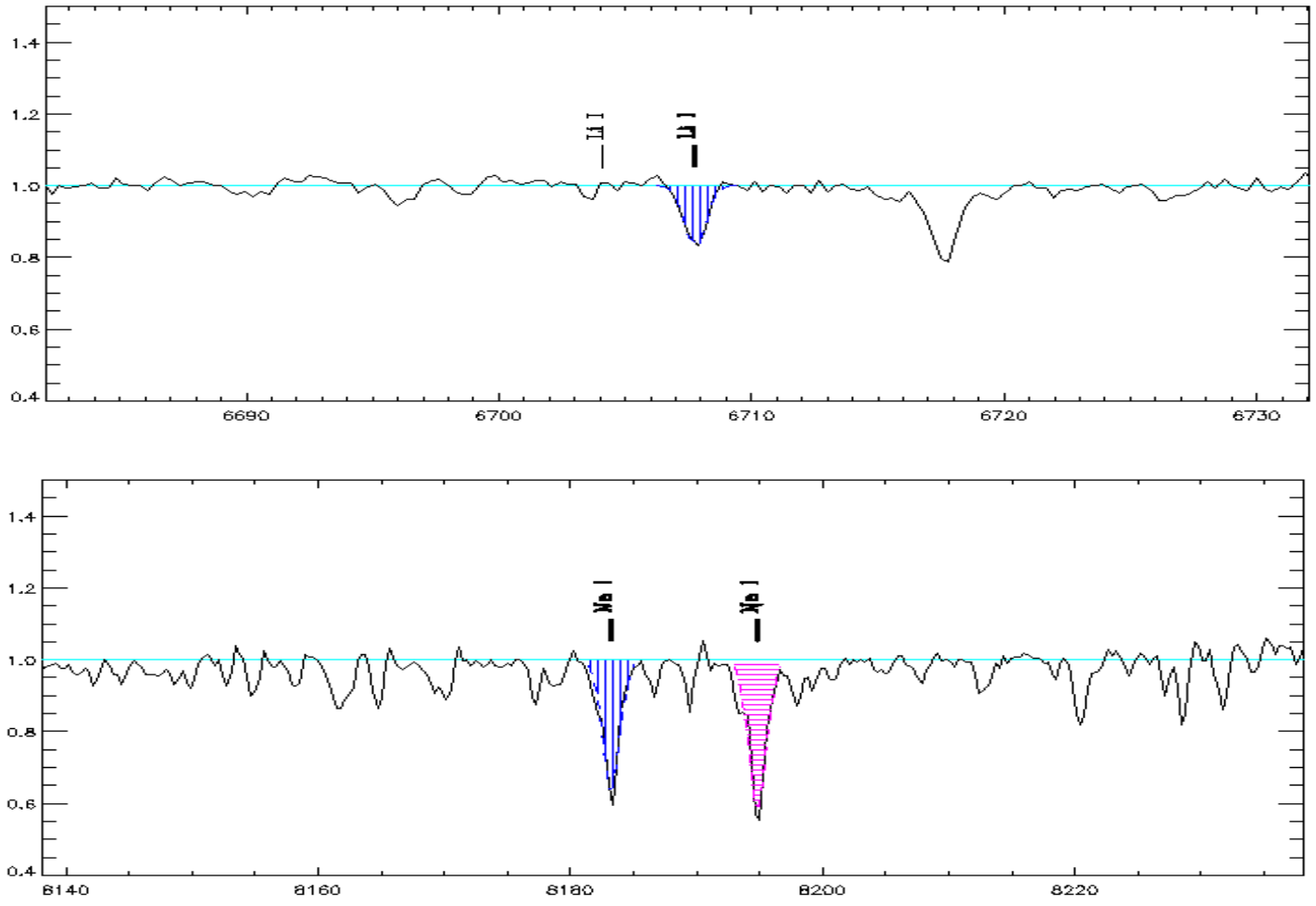
Domínguez et al. A&A 422, 1045-1052 (2004)

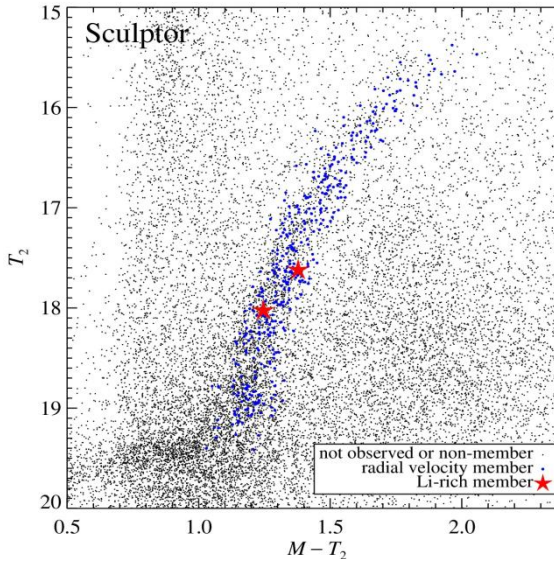
670092 in Draco

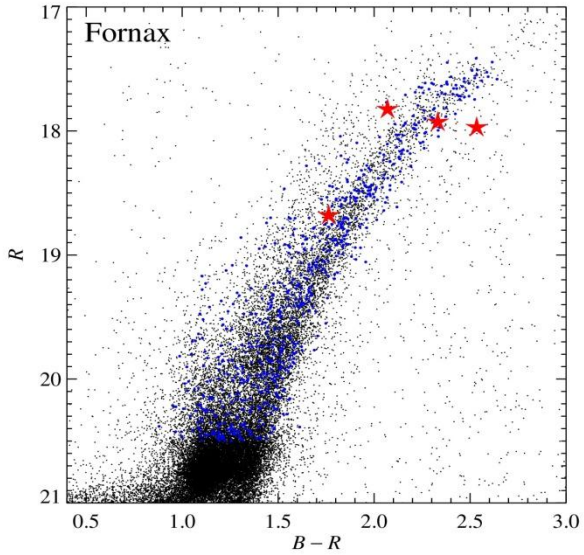


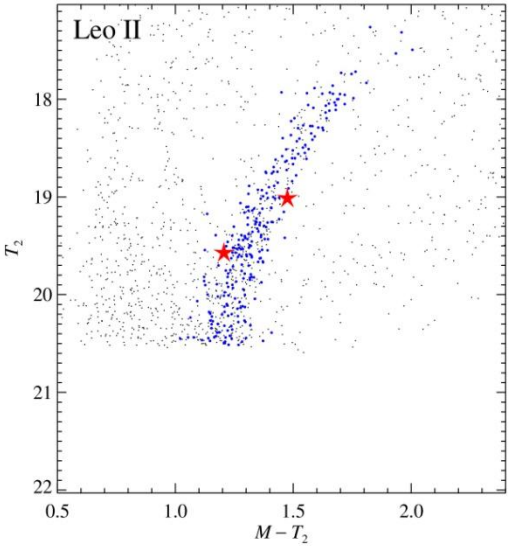
How we tell they are Giants in dSph

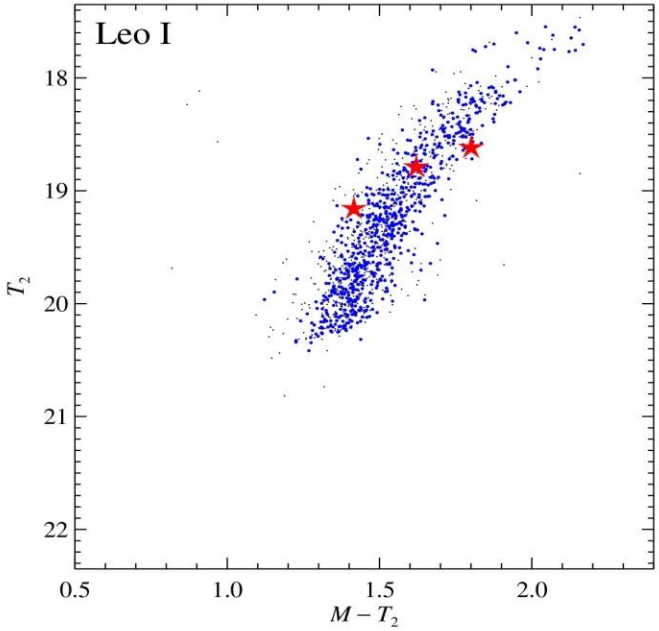
✓ They are not dwarf nearby: check the Na doublet near 8190 Å

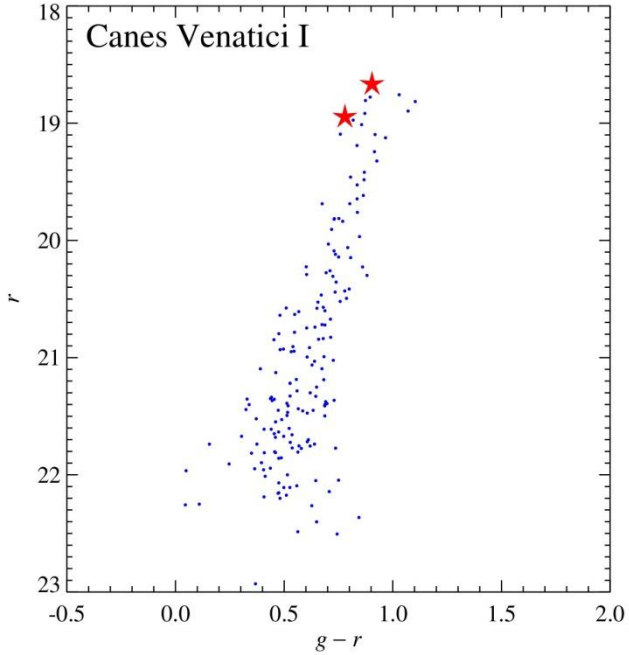






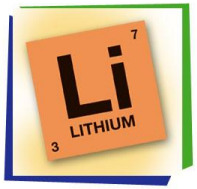






Kirby, Fu & Guhathakurta, Deng, to be submitted to ApJ

How we tell they are Giants in dSph



- ✓ They are velocity (Vhelio) members
- ✓ They are at right position in CMD

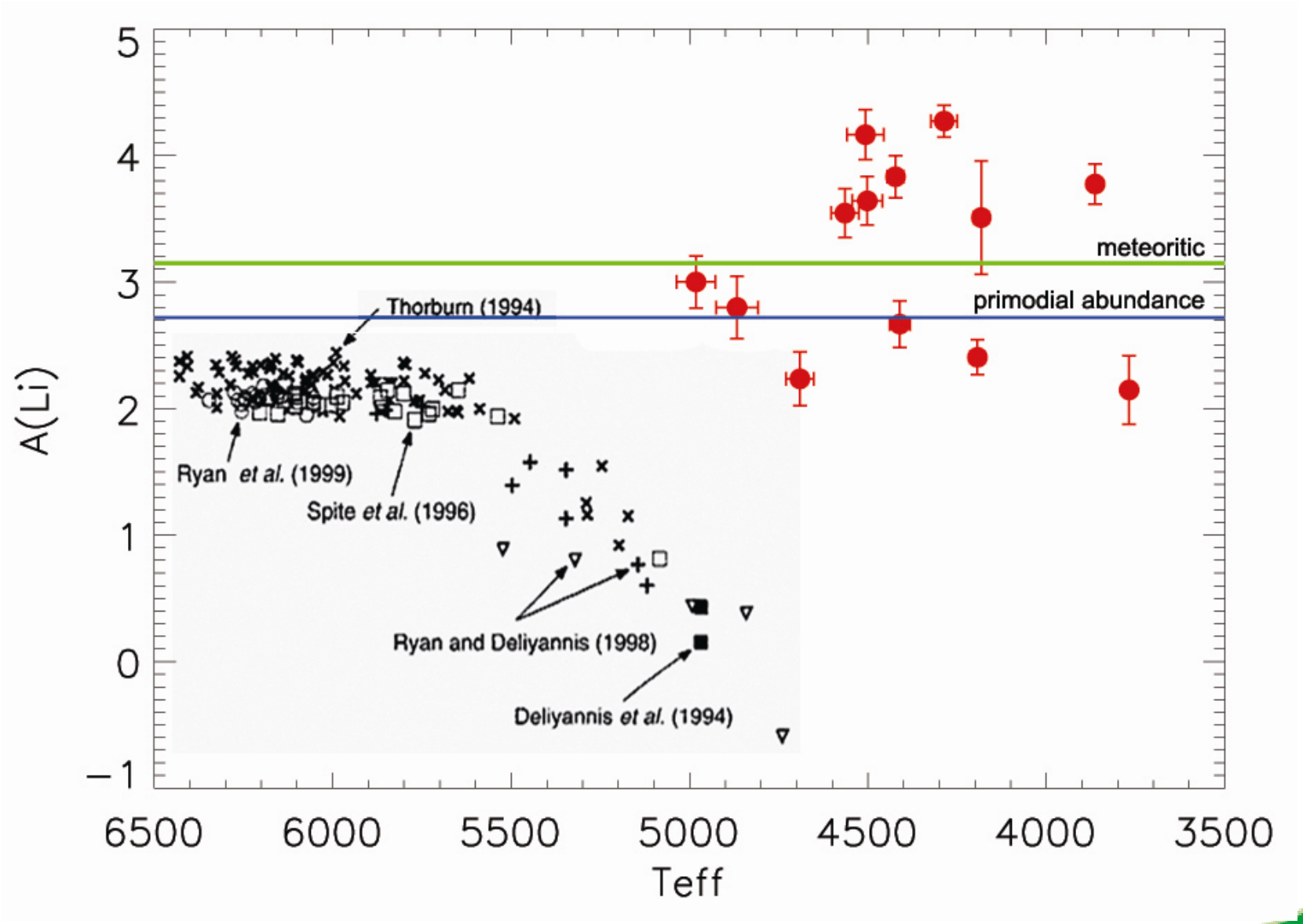
We get 2961 members in the 8 dSphs from 4880 stars

Sculptor Fornax Leo I

Leo II Canes Venatici I

Lithium abundance analysis

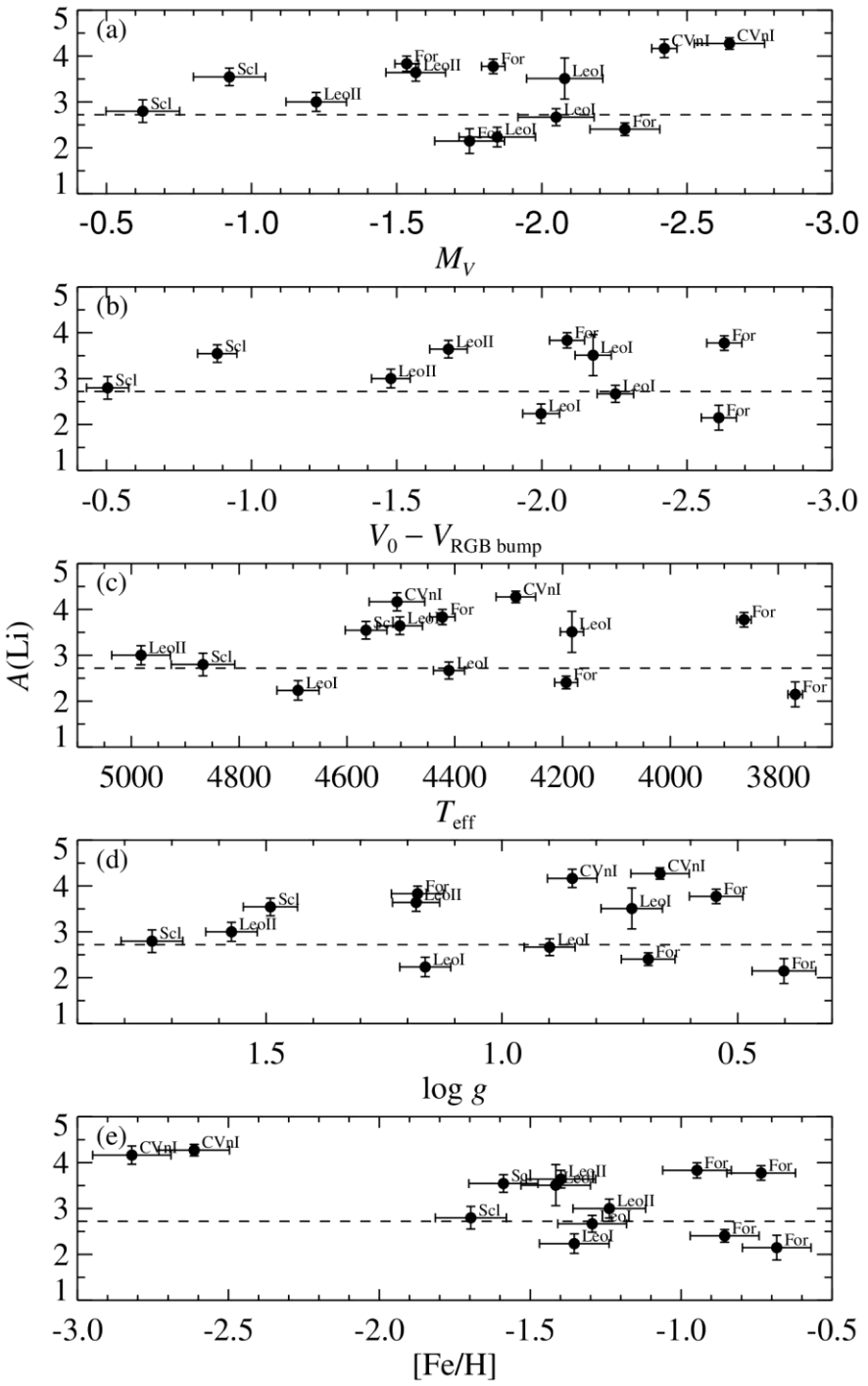
ATLAS9 atmosphere model and MOOG



Lithium abundance analysis

The Li-rich giants show no correlation with evolutionary state.

Kirby, Fu & Guhathakurta, Deng, to be submitted to ApJ



How to explain the existence of Lithium?

Explanation 1

By the ingestion

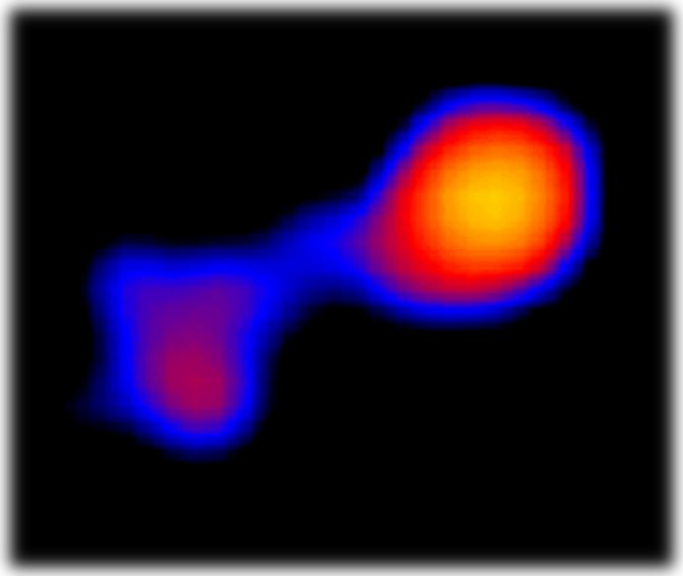
of a planet or a brown dwarf because of the expansion of the stellar atmosphere

BUT,

Still Metal-poor

mass transfer

from a AGB companion.
The massive AGB can produce lithium via Hot Bottom Burning (HBB).

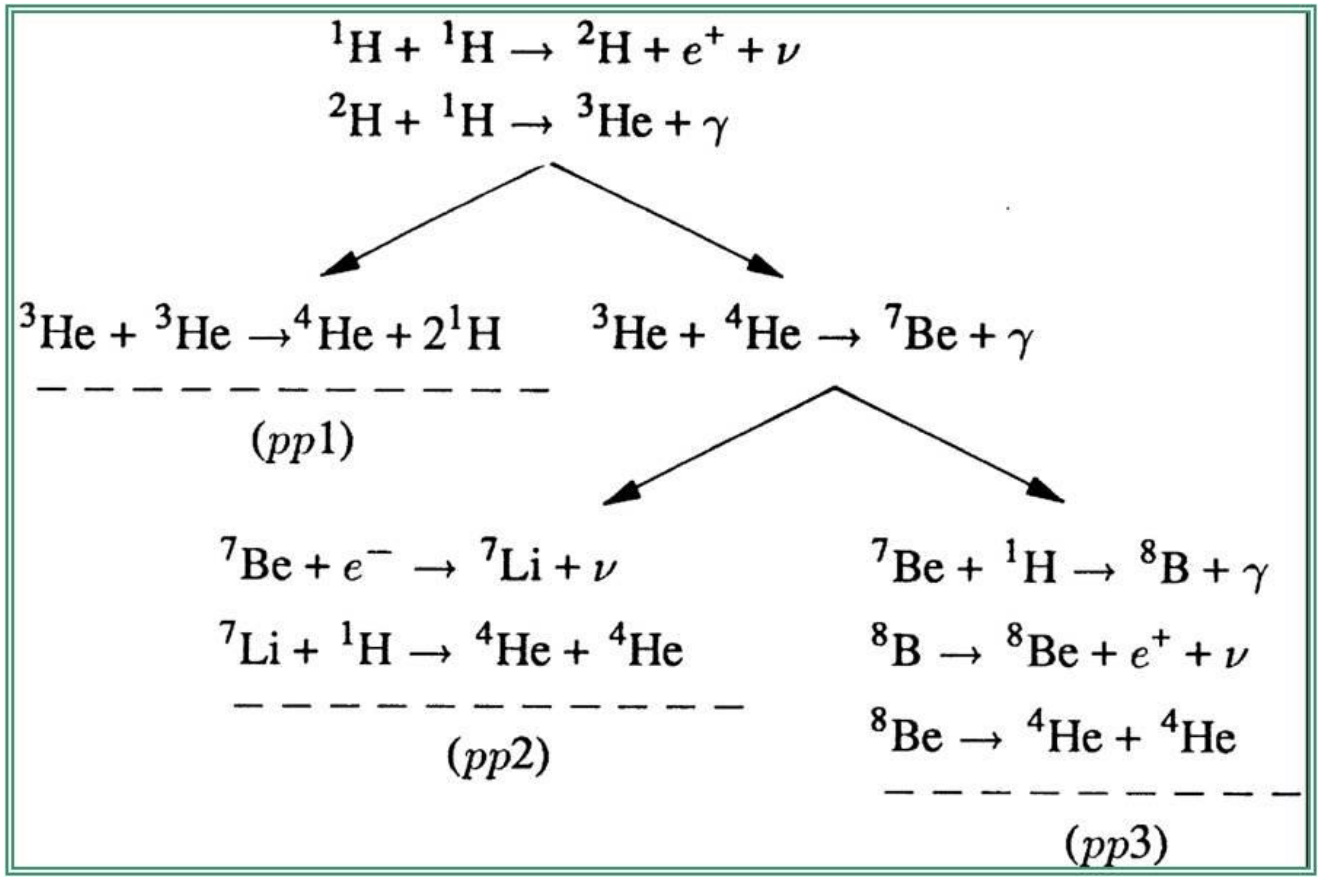


BUT,

the dSphs are too old to have the massive AGB in 4-7 solar mass.

Explanation 3:

The giant stars **produced** fresh Lithium themselves.



Cameron & Fowler (1971)

Explanation 3:

- Cool Bottom Processing (CBP)?

  Sackmann & Boothroyd, 1999

- Lithium flash?

  Palacios et al. 2001

- Lithium circumstellar shell?

  de la Reza et al. 1996

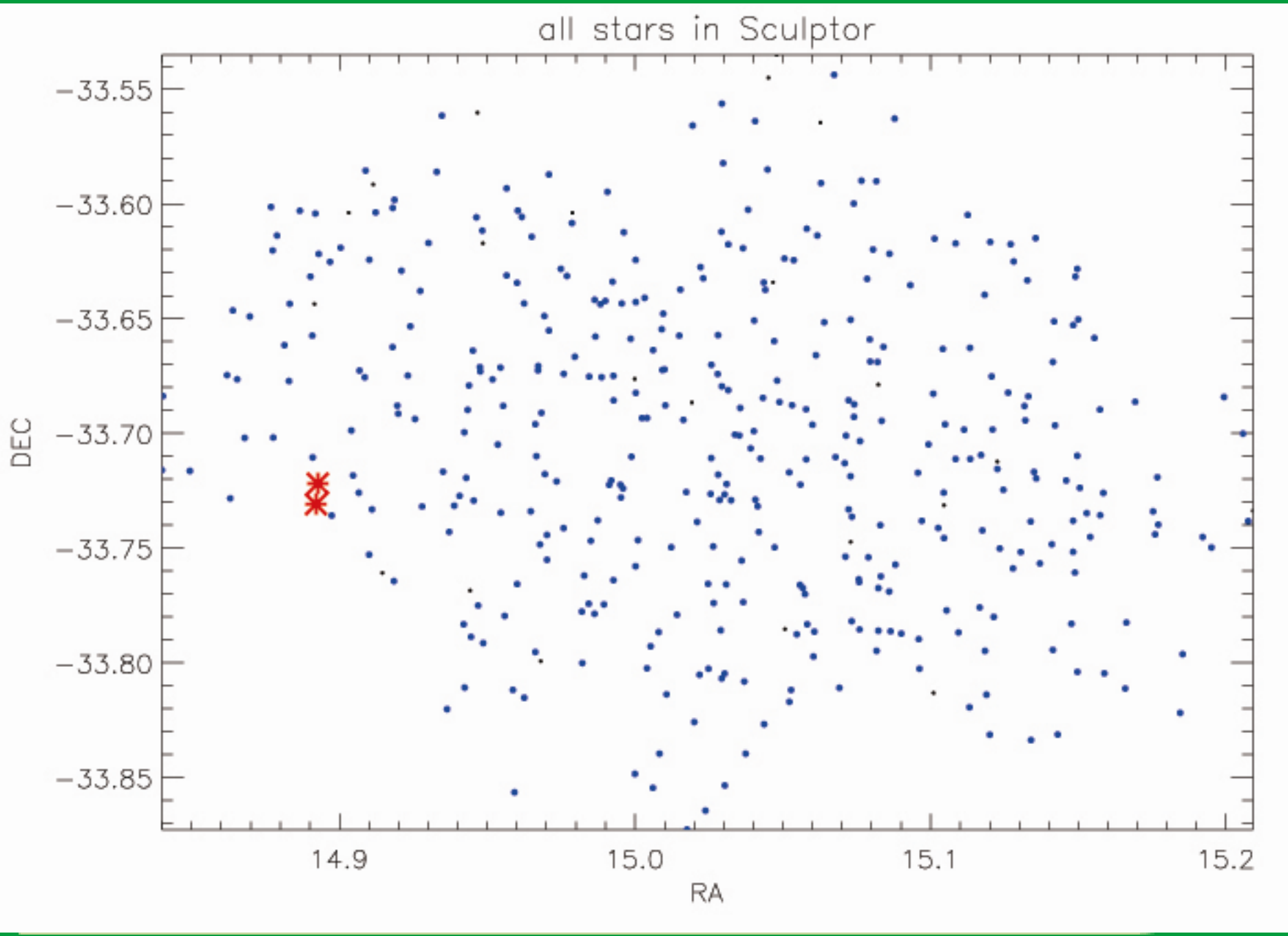
Still a challenge for standard stellar evolution models

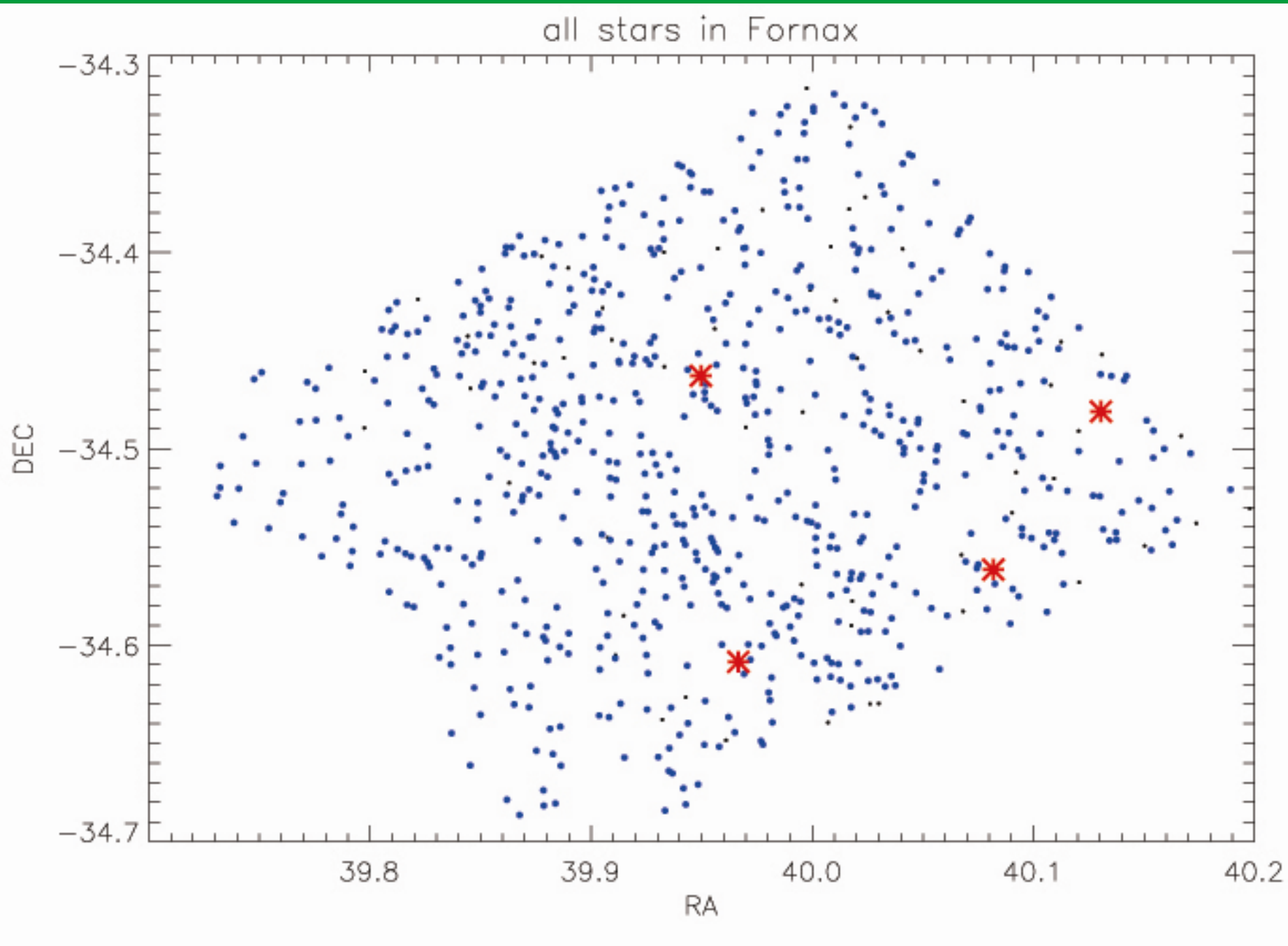
High resolution spectra follow up?

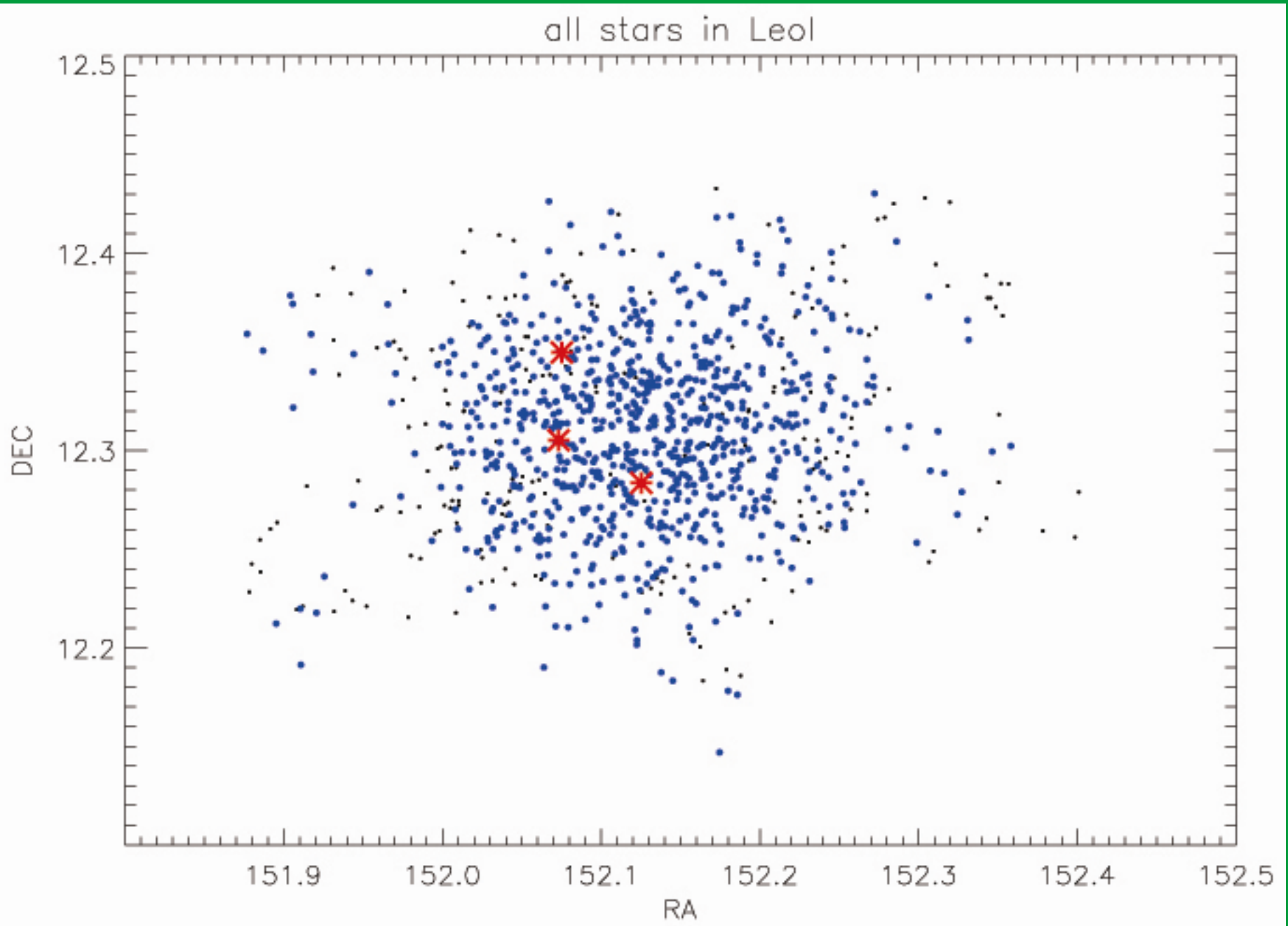
Conclusion:

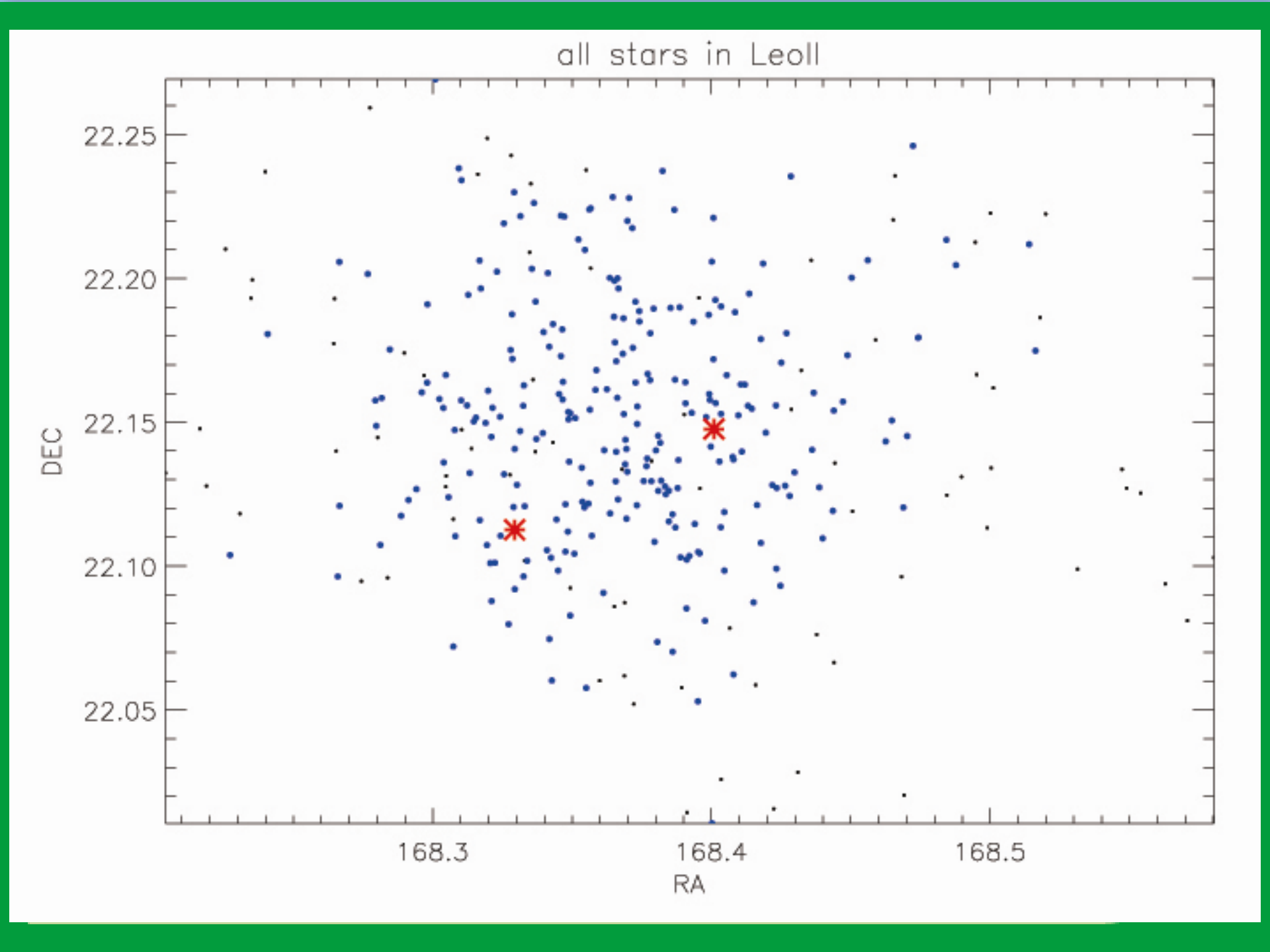
- **13 super lithium-rich red giants are present in Milky Way dwarf galaxies: Sculptor, Fornax, Leo I, Leo II and Vanes Venatici I.**
- **The Li-rich giants show no correlation with evolutionary state.**
- **The lithium in these stars must have been created in the RGB themselves rather than saved from destruction.**
- **We are now calculating the lithium abundance upper limit to every single giants in the dwarf galaxies and make lithium distribution comparison among the dSphs, field stars and Globular Cluster**

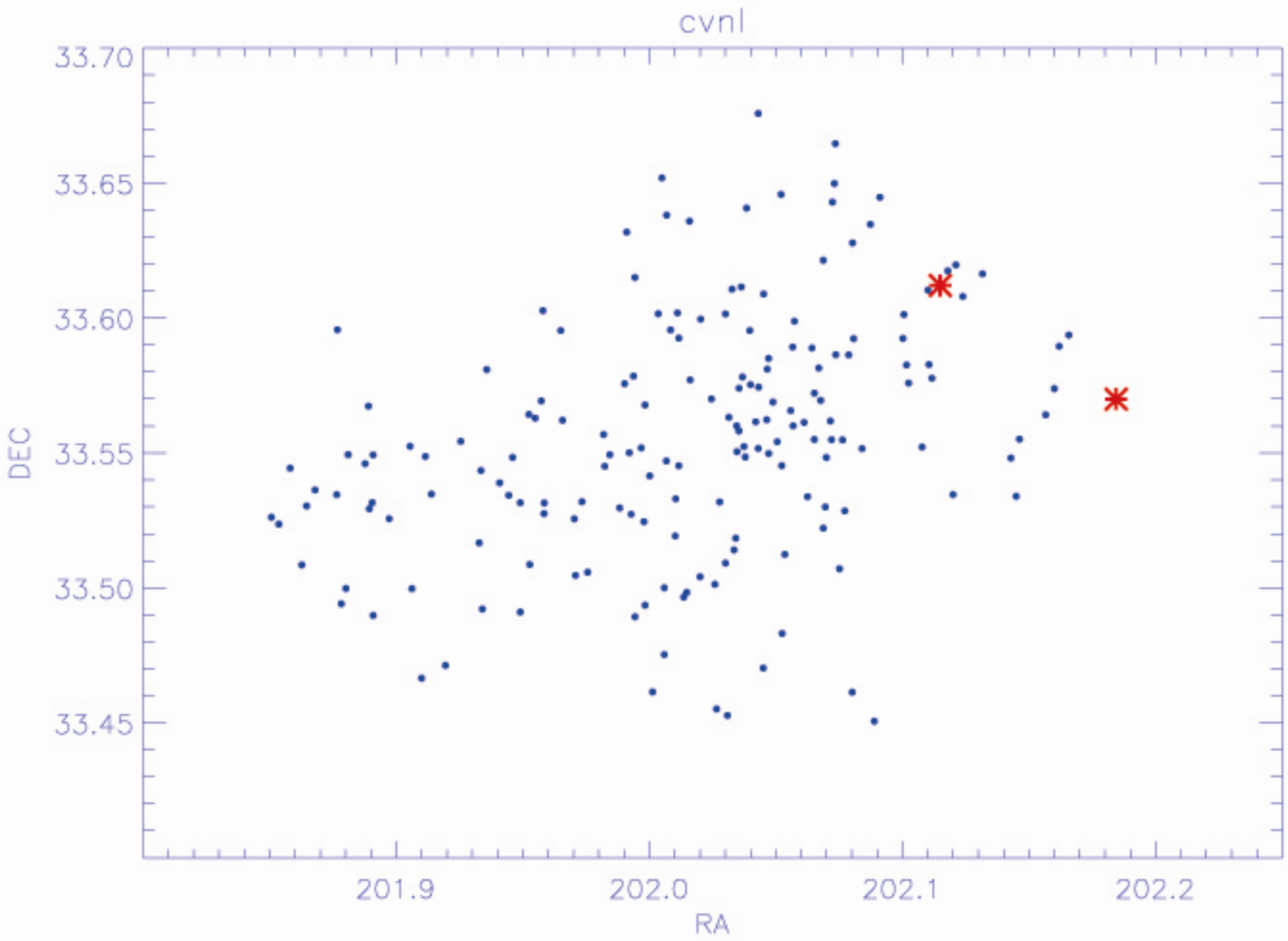
Thank you!


all stars in Sculptor
−33.55
−33.60
−33.65
−33.70
−33.75
−33.80
−33.85
DEC
14.9
15.0
15.1
15.2
RA


all stars in Fornax
−34.3
−34.4
−34.5
−34.6
−34.7
DEC
39.8
39.9
40.0
40.1
40.2
RA


all stars in Leol
12.5
12.4
12.3
12.2
DEC
151.9
152.0
152.1
152.2
152.3
152.4
152.5
RA


all stars in Leo II
22.25
22.20
22.15
22.10
22.05
DEC
168.3
168.4
168.5
RA


cvnl
33.70
33.65
33.60
33.55
33.50
33.45
DEC
201.9
202.0
202.1
202.2
RA