The contribution of ESO to the study of stellar beryllium abundances

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INTRODUCTION

Beryllium is a light element with a single stable isotope (^{9}Be) produced only by cosmic-ray spallation in the interstellar medium.

Measurement of Be abundances in different types of stars provide a key tool to investigate a number of astrophysical problems, including primordial nucleosynthesis, Galactic chemical evolution, stellar evolution and the formation of globular clusters.

The two BeII resonance lines useful for abundance analyses are at the near-UV (~ 3130 Å), a region strongly affected by atmospheric extinction.

PAPERS AND CITATIONS

As of 23.08.2012, a total of 23 refereed papers about stellar Be abundances have used data obtained with ESO telescopes. The first one being Molaro et al. (1997) and the last one Delgado Mena et al. (2012). The authors of this poster are part of more than half of these papers.

The numbers correspond to an average of 3 refereed papers every 2 years. These papers have a total of 475 citations (at ADS), an average of ~20.6 citations per paper.

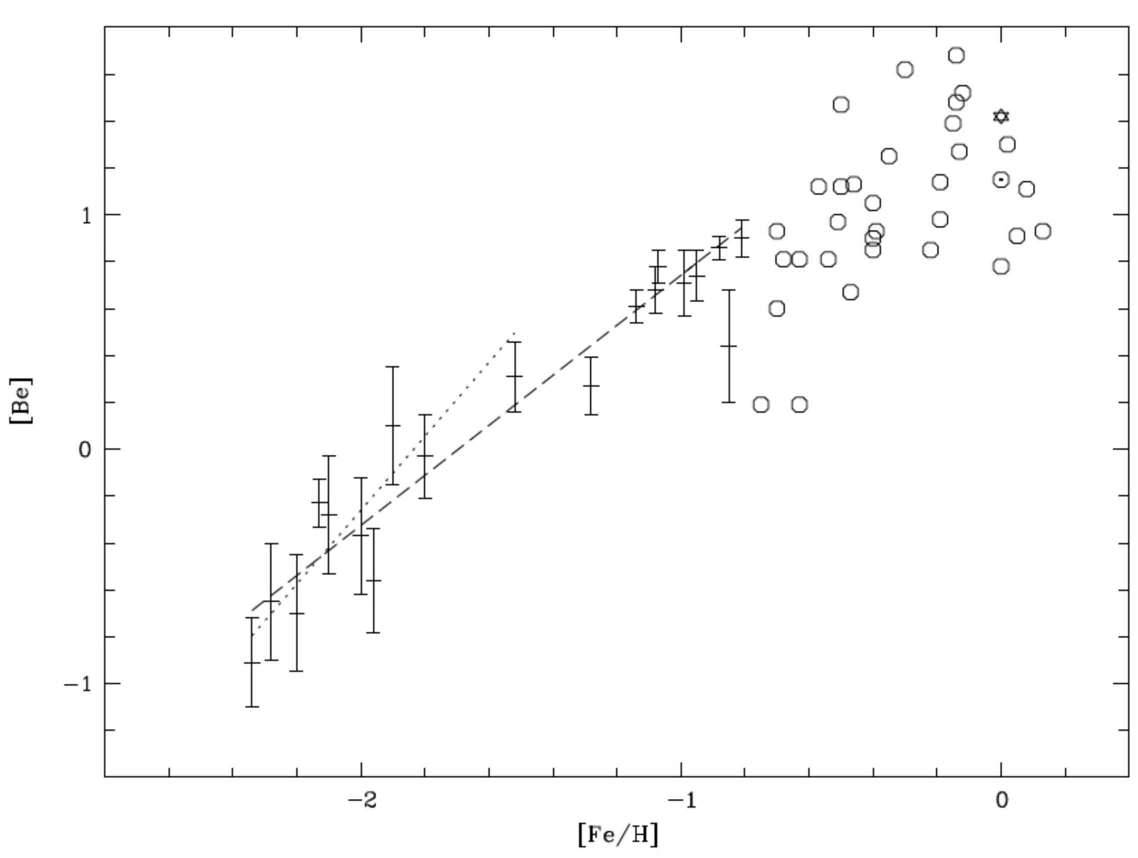

Fig. 02 – Linear relation between Be and [Fe/H] as obtained in Molaro et al. (1997).

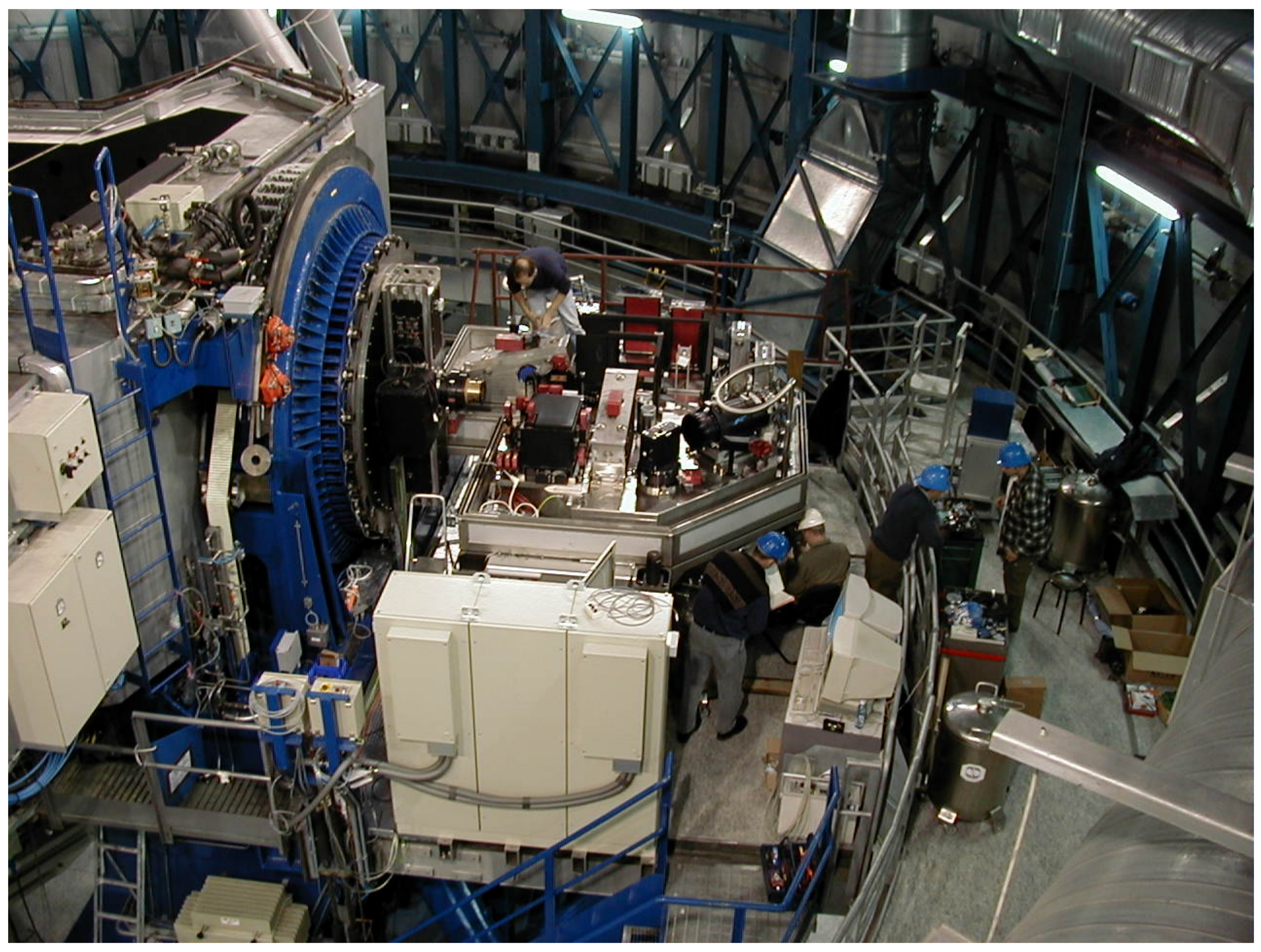

Fig. 01 – UVES being installed at the UT2. **Credit: ESO**

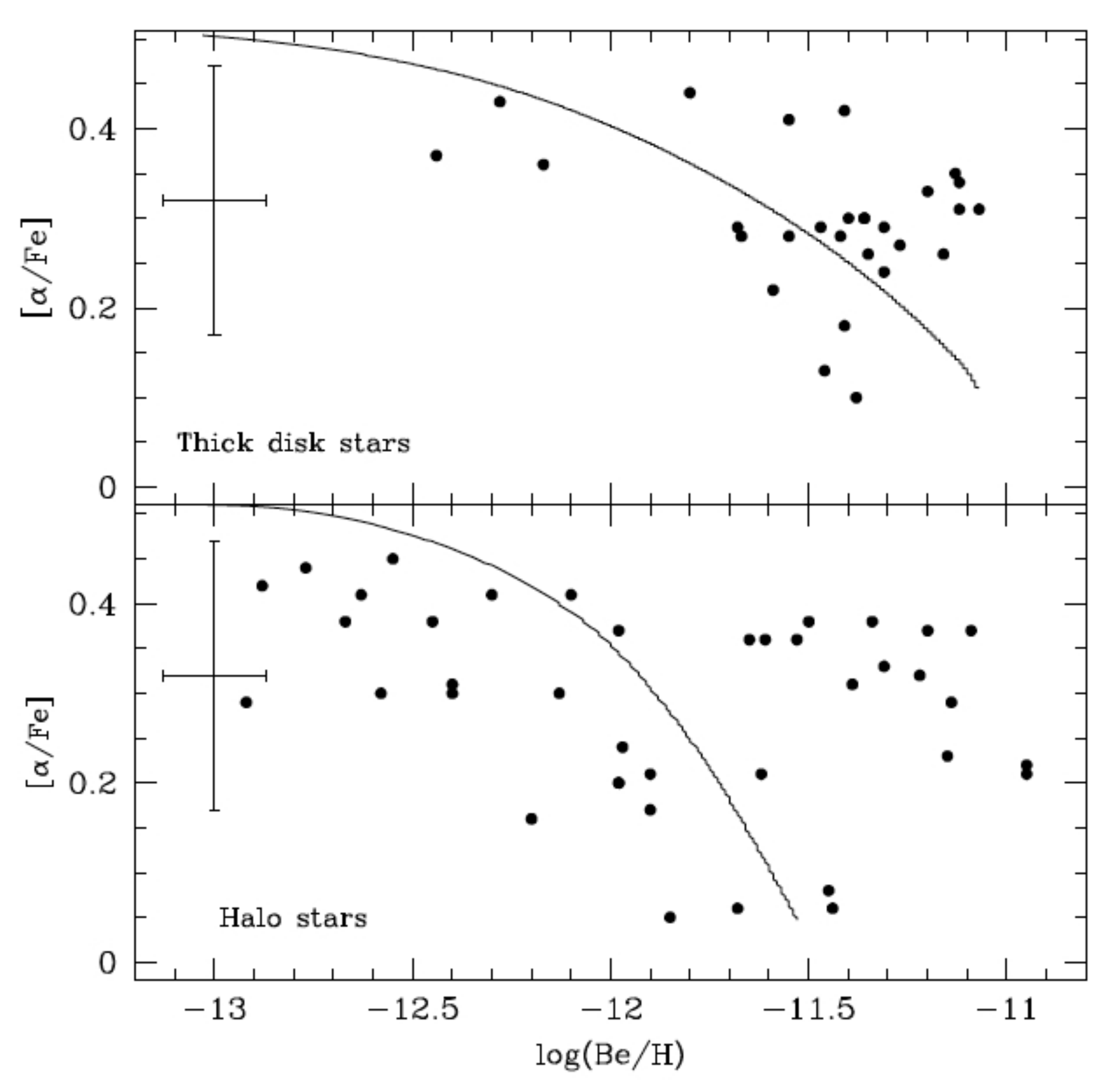

Fig. 03 – Diagram of log (Be/H) vs. [α/Fe] for the halo stars and thick disk stars studied in Smiljanic et al. (2009).

THE INSTRUMENTS

Two ESO spectrographs have been used to obtain high-resolution spectra at this wavelength range:

1) **CASPEC at the 3.6m telescope in La Silla**
2) **UVES at the VLT in Paranal.**

CASPEC (Cassegrain ESO Echelle Spectrograph) started operations at the 3.6m telescope in 1983. Depending on the choice of grating and slit width, it could obtain spectra with up to R ~ 60000.

UVES (Ultraviolet and Visual Echelle Spectrograph – Fig. 01) started operations at the UT2/VLT in 1999. It has a maximum resolution of R ~ 80000 in the blue arm.

One future instrument is planned to maintain the ESO capability of obtaining spectra in the near-UV, CUBES (Cassegrain U-band Brazilian ESO Spectrograph). It is currently planned to obtain spectra with R ~ 20000 in the near-UV.

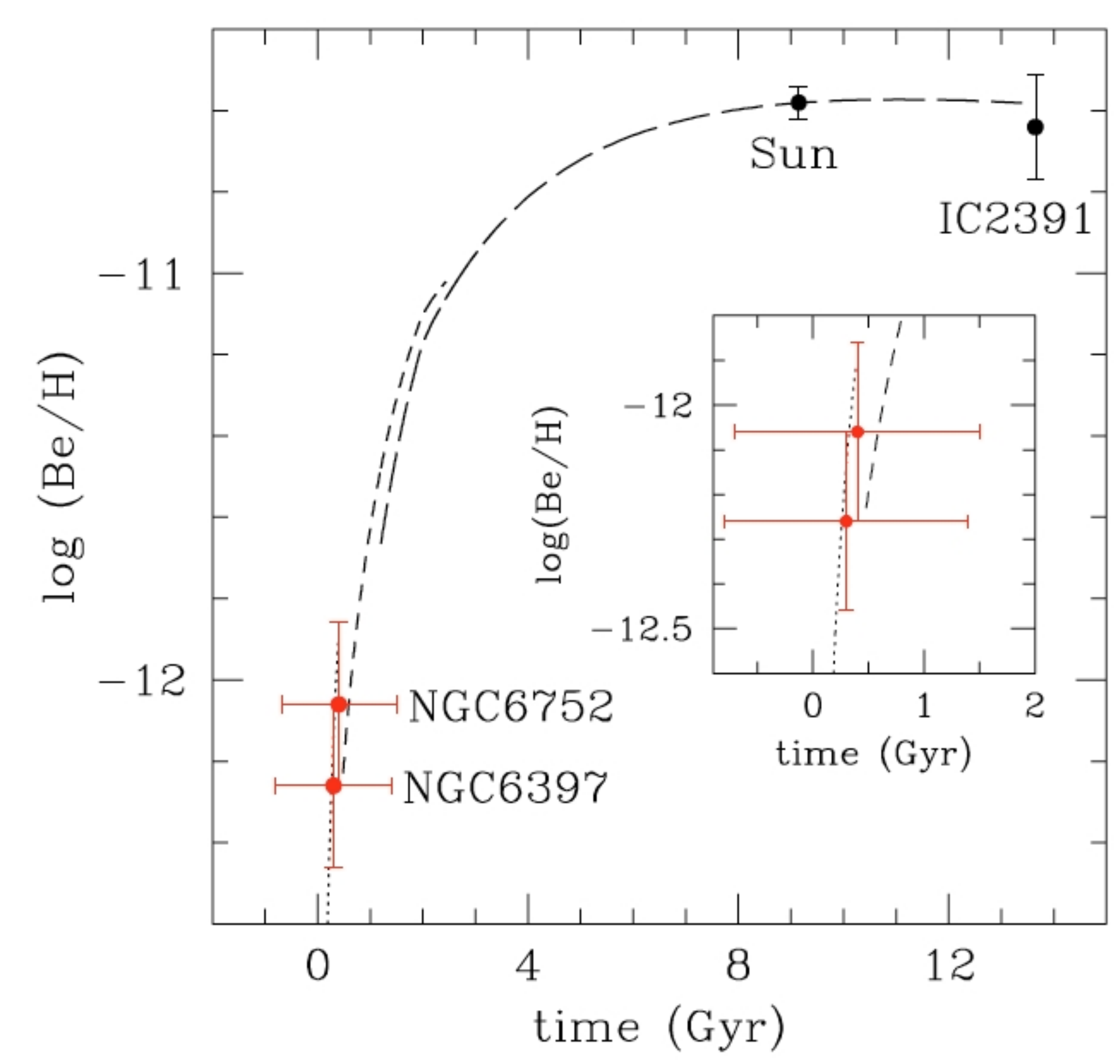

Fig. 04 – Be abundance in the GCs of Pasquini et al. (2004, 2007) in comparison to a model of the evolution of Be abundance with time.

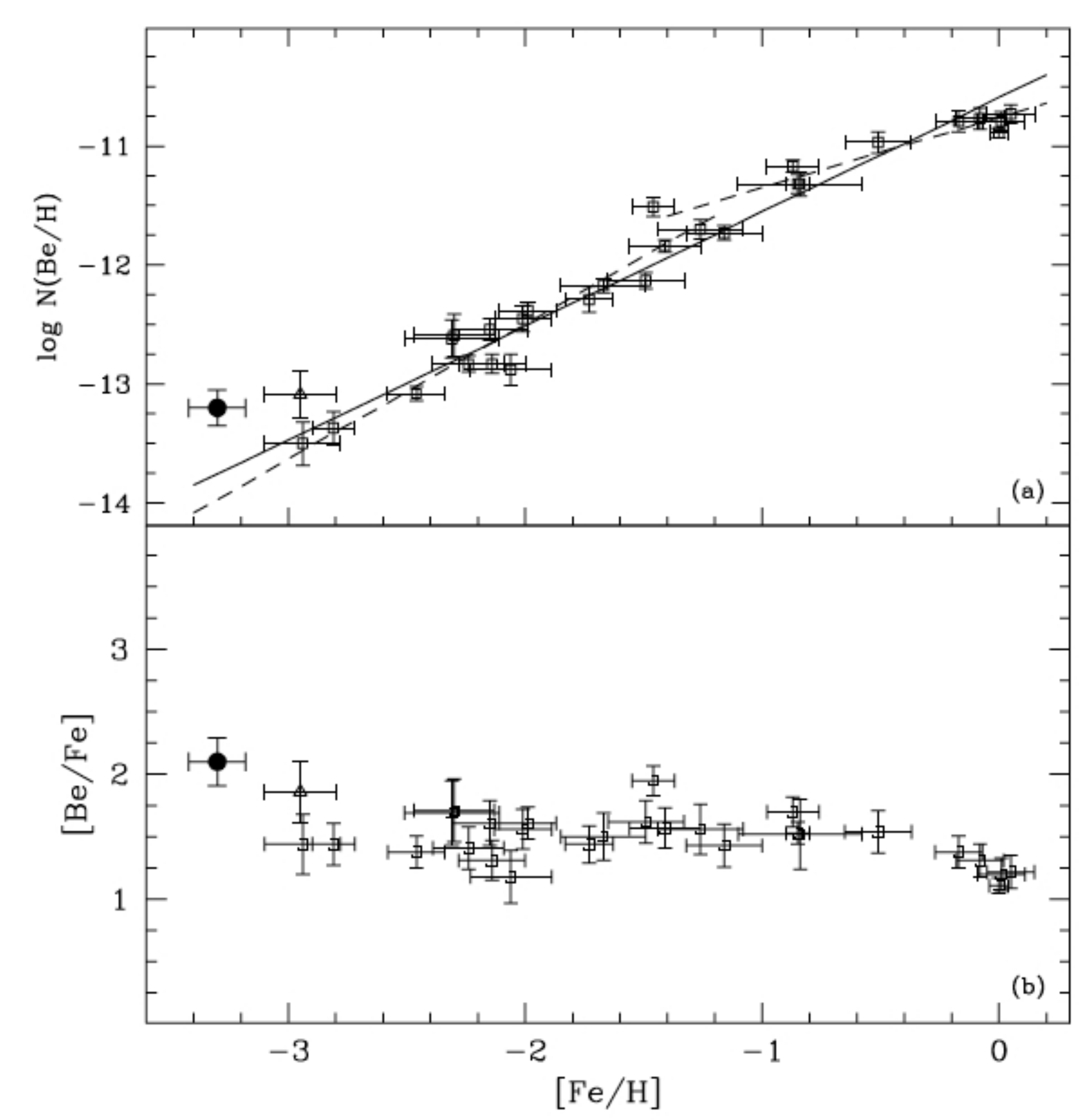

Fig. 05 – The metal-poor star G64-12 of Primas et al. (2000); a flattening of the linear relation?

SCIENCE

Abundances of Be in connection with mixing episodes have been investigated in young main-sequence stars, F-type and solar-like stars, subgiants and giants of open clusters and of the field (Randich et al. 2002, Santos et al. 2004, Garcia Perez & Primas 2006, Randich et al. 2007, Smiljanic et al. 2010, 2011). The results have contributed to show that low-mass stars may deplete a certain amount of Be during the main sequence, depending on their masses, that Be is also strongly depleted in F-type stars of the Li-dip, that stars like the Sun do not deplete Be, and that subgiants have enhanced Be depletion with respect to the one predicted by models.

The evolution of Be in the Galaxy was investigated with ESO data by Molaro et al. (1997), Smiljanic et al. (2009), Tan et al. (2009) and Tan & Zhao (2011). The results helped to confirm that the Li in popII stars is primordial and not made by spallation processed, that Be abundances have a linear relation with [Fe/H] (Fig. 2), and that the halo is formed by two stellar components, one with low- and one with high-[alpha/Fe] (Fig. 3).

Abundances of Be have been determined in stars of two globular clusters (GCs), NGC 6397 and NGC 6752 (Pasquini et al. 2004, 2007). The abundances were used to test the use of Be as a cosmochronometer (Fig. 4) and to investigate the origin of the CNO processed material that causes the abundance correlations and anti-correlations observed in GCs. The Be abundances seem to be hard to explain within a simple pollution/dilution scenario.

Two stars with enhanced Be abundances have been found with ESO data. Star J37 in the open cluster NGC 6633 with A(Be) = 3.0 and [Fe/H] = +0.67 (Ashwell et al. 2005) and HD 106038 with A(Be) = 1.40 and [Fe/H] = -1.26 (first noticed by Asplund et al. 2006 and further analyzed by Smiljanic et al. 2008). The former seems to have accreted material with composition similar to chondritic meteorites. The later, is suggested to be contaminated by the products of a hypernova.

The most metal-poor stars observed with ESO spectrographs and where Be has been detected were presented by Primas et al. (2000a,b). The abundance of G64-12 with [Fe/H] = -3.30 may suggest a flattening of the Be x Fe relation (Fig. 5), a feature still under discussion and where CUBES might make a decisive contribution.

Beryllium abundances have also been investigated in lithium-rich stars (Castilho et al. 1999, Melo et al. 2005). No detection of Be was possible, showing that the stars have gone through mixing episodes and that Li has been produced by these stars.

Finally, a number of papers have also investigated whether stars hosting giant planets have different Be abundances from stars without planets (Santos et al. 2002,2004b, Galvez Ortiz et al. 2011, Delgado Mena et al. 2011, 2012). No significant difference has been found.