# Disentangling massive AGB stars and red supergiants

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# Introduction: Observational differences between AGBs and SGs

**Supergiants and RGB/AGB stars are differentiated by their inner processes.**
**Are there external (observational) differences?**

| Observable | Differentiation | Problems and limitations |
|---|---|---|
| Colours | None | - Similar temperatures<br>- Both have extended atmospheres |
| Luminosity | (Most) supergiants are more luminous than (most) AGBs | - Low luminosity SGs and super-AGBs present the same typical luminosities<br>- Frequently, distances (and interstellar reddening) are unknown |
| Spectra | At mid resolution, luminosity-related spectral features | - At similar luminosity, the differences are very subtle |
| Variability | AGBs have spectral and photometric variations more extreme than (most) SGs | - Most SGs are photometric variables<br>- Some SGs present extreme variations similar to those of AGBs<br>- Very long periods (as long as 900 d) |

**Alternative method: statistical analysis of a large spectral sample**

# The sample: Selection, observation and classification

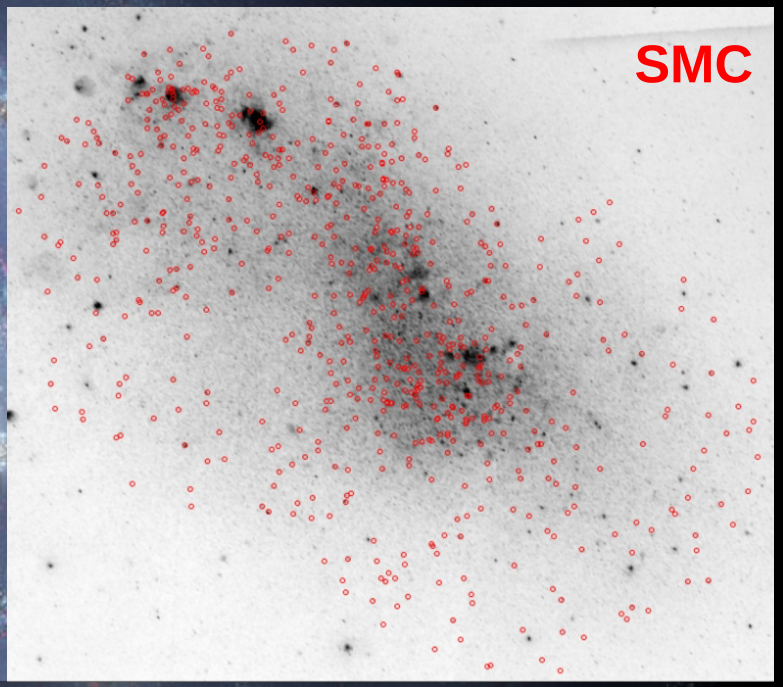
**Sample selection:** (González-Fernández 2015)
- Previously known cool supergiants from the Magellanic Clouds Elias et al. (1985), Massey & Olsen (2003), and Neugent et al. (2010)
- Candidates selected through the free-reddening parameter $Q_{IR}=(J-H)-1.8(H-K_S)$

**Observations:** AAOmega dual beam multiobject spectrograph (Anglo-Australian Telescope):
- Optical range: 580V (R~1300) and 1500V (R~3700)
- Ca Triplet spectral range: 1700D (R~11000)

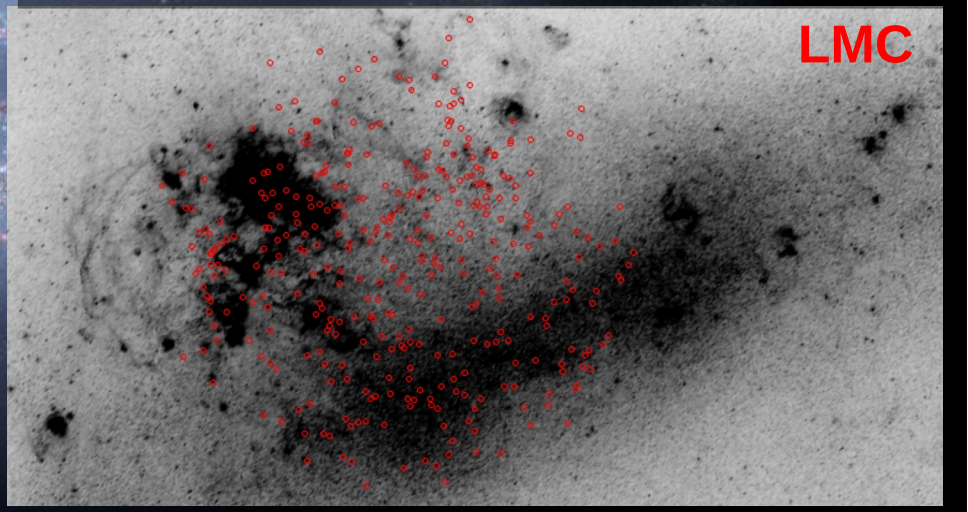
**Classification:** Spectral type (SpT) and luminosity class (LC) were determined through the optical range. Non-members from the MCs filtered by RV (González-Fernández 2015)

**Bolometric magnitudes (for CSGs):** Through $(J-K)$ (Bessell & Wood 1984)

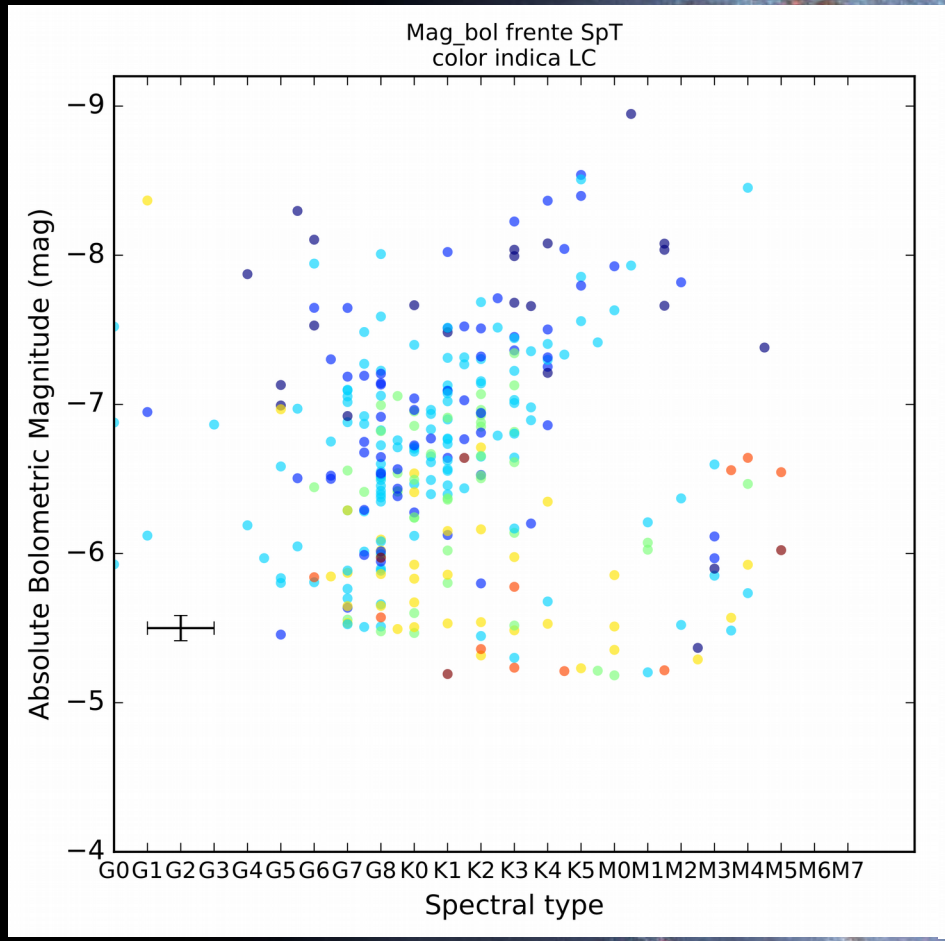
**FINAL SAMPLE:**
>500 cool supergiants (LC Ia to Ib)
~40 RGB/AGBs (LC Ib–II, II)



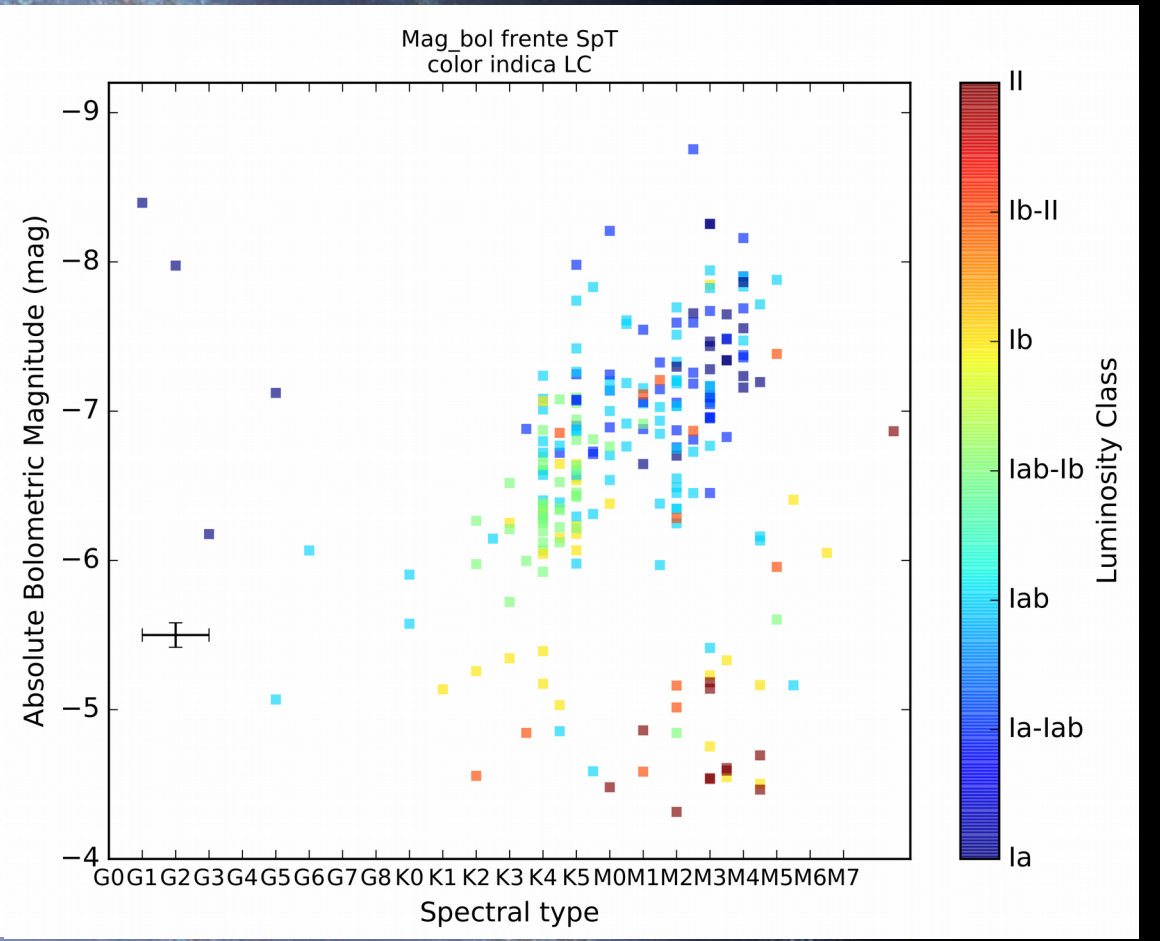

Spatial distribution of targets in the LMC (below, 2ºx4º) and the SMC (above, 3ºx3º), over DSS-Red images. Note that in the LMC the only field observed covers less than 50% of the galaxy.



# Spectral type and Bolometric magnitude
## (Dorda et al. 2016a)




Supergiants and AGBs from the SMC

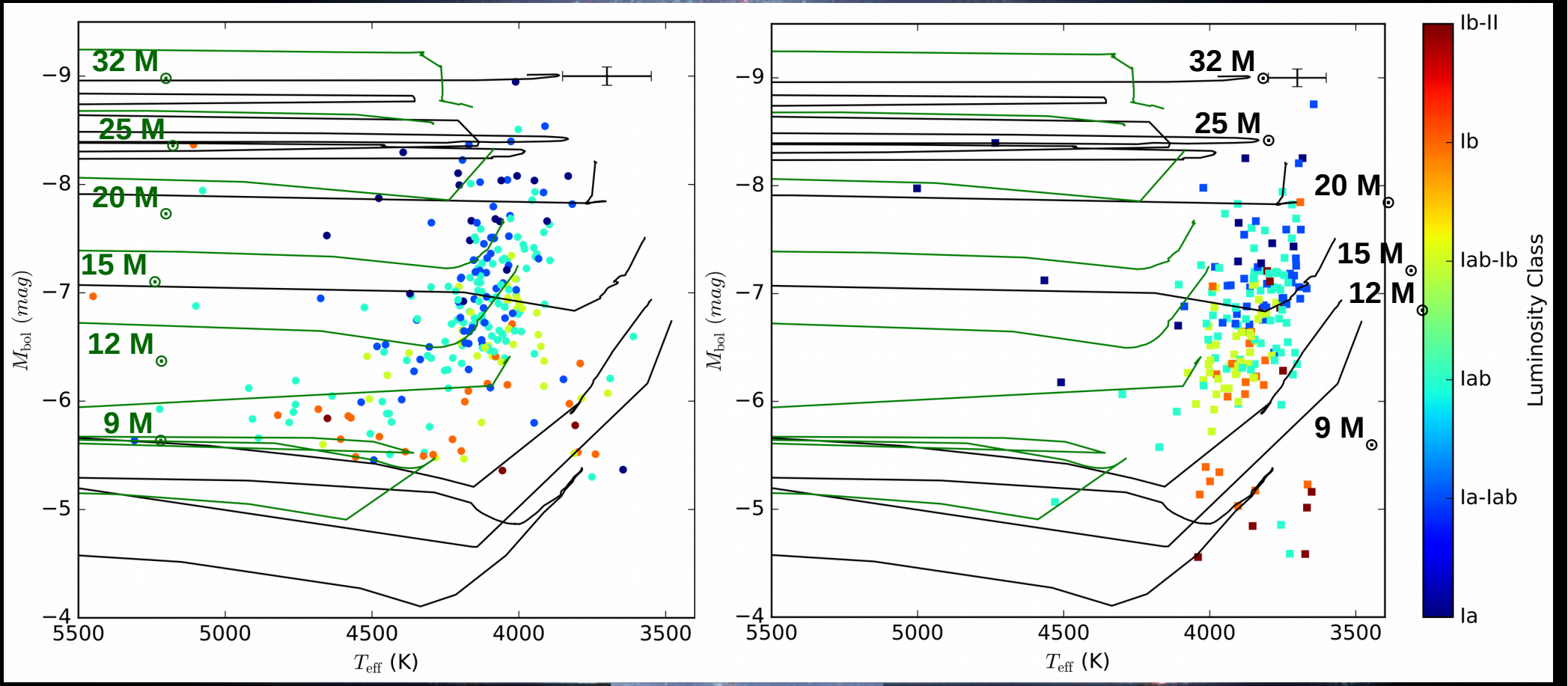



Supergiants and AGBs from the LMC

- Correlation between luminosity and SpT for Ia and Iab supergiants.

- Most Ib, Ib–II, and II exhibit a different behaviour.

# Hertzsprung-Russel Diagram
## (Tabernero et al. In prep.)




Supergiants and AGBs from the SMC

Supergiants and AGBs from the LMC

Geneva Evolutionary tracks for:
Black lines - Solar metallicity (Ekström et al. 2012)
Green lines - Typical metallicity of the SMC (Georgy et al. 2013)

- Supergiants that follow the SpT-Mbol trend: seem to have 10-12 $M_\odot$ or more

- Ib, Ib–II, and II stars seem to have ~9 $M_\odot$

# Automated spectral identification
## (Dorda et al. 2016b)

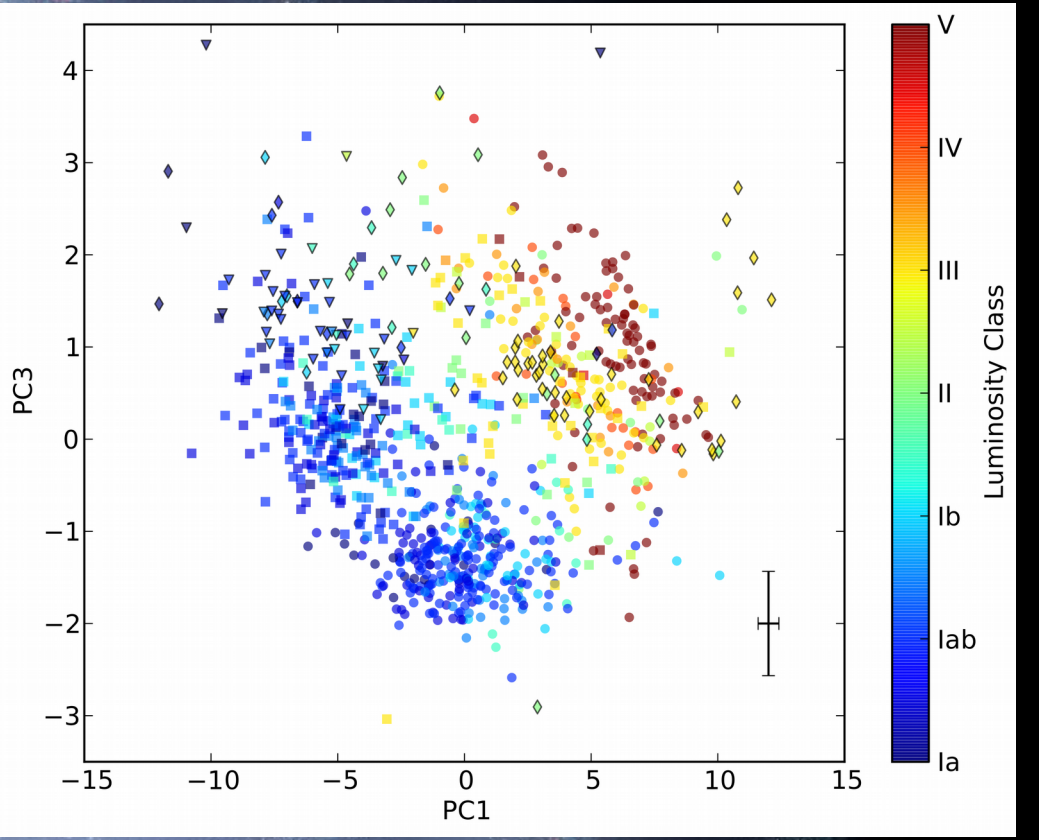
**Automated method for identification of cool supergiants:**

**- Training sample: from the MCs plus a sample from the Galaxy.**

**- Measure: 32 spectral features in the Calcium Triplet spectral range.**

**- Principal Components of the spectral features.**

**- Boundaries between supergiants (Ia to Ib–II) and non-supergiants: Support Vector Machine method was used on the Principal Components space.**




**Example of diagram for luminosity class identification: Principal Componenst 1 and 3**

**High efficiency (95%) and low contamination (<3%) recovering the original sample.**

# Applying the automated spectral identification
## (Dorda et al. In Prep.)

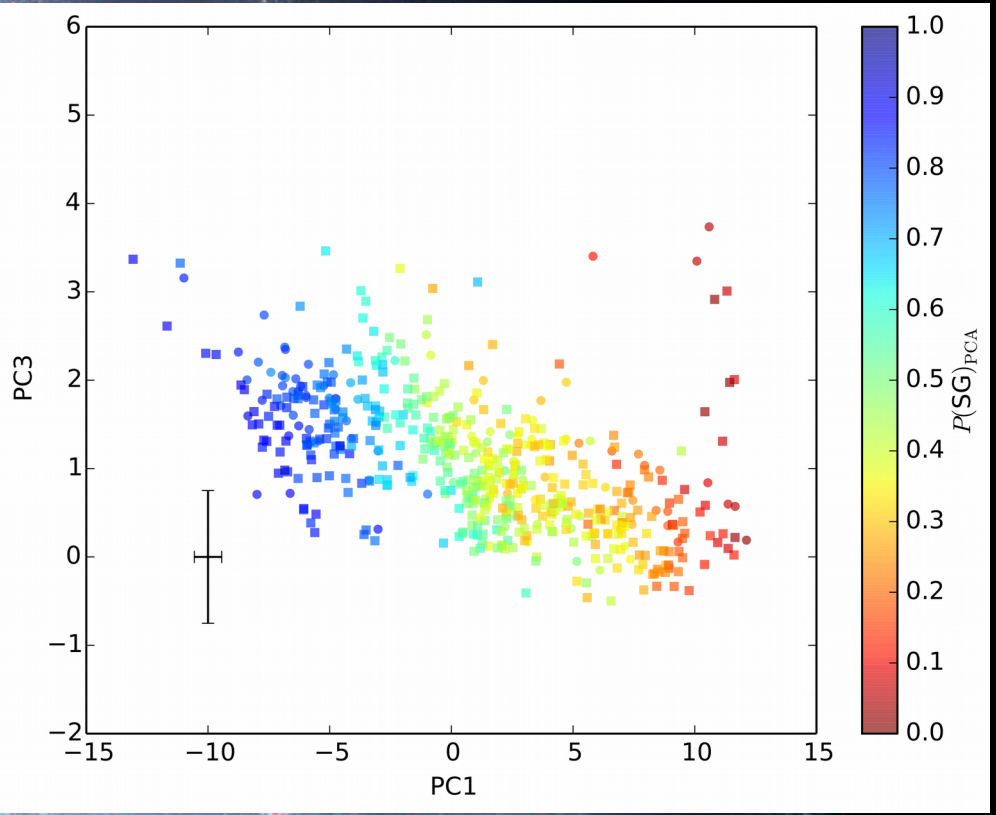
**Problem sample: 637 stars photometrically selected, from the Perseus arm.**

**Results:**

**- 191 supergiants identified through the automated method.**
**- 256 supergiants identified through a visual classification with classical criteria.**

**Difference: Almost all (60) were Ib-II stars which were not identified as supergiants.**

**With Gaia, we will test if these Ib-II stars are AGB stars through their magnitudes.**




**Example of diagram for luminosity class identification: Principal Components 1 and 3**

**Our automated method is capable of taking advantage of the statistical information contained in the spectra, to split the supergiants from AGBs and red giants.**

**It can be adapted for the specific identification of super-AGBs and AGBs.**

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**Thank you very much**

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