Systematic effects in radial velocity and chemical abundance determinations: the case of FORS2 and FLAMES

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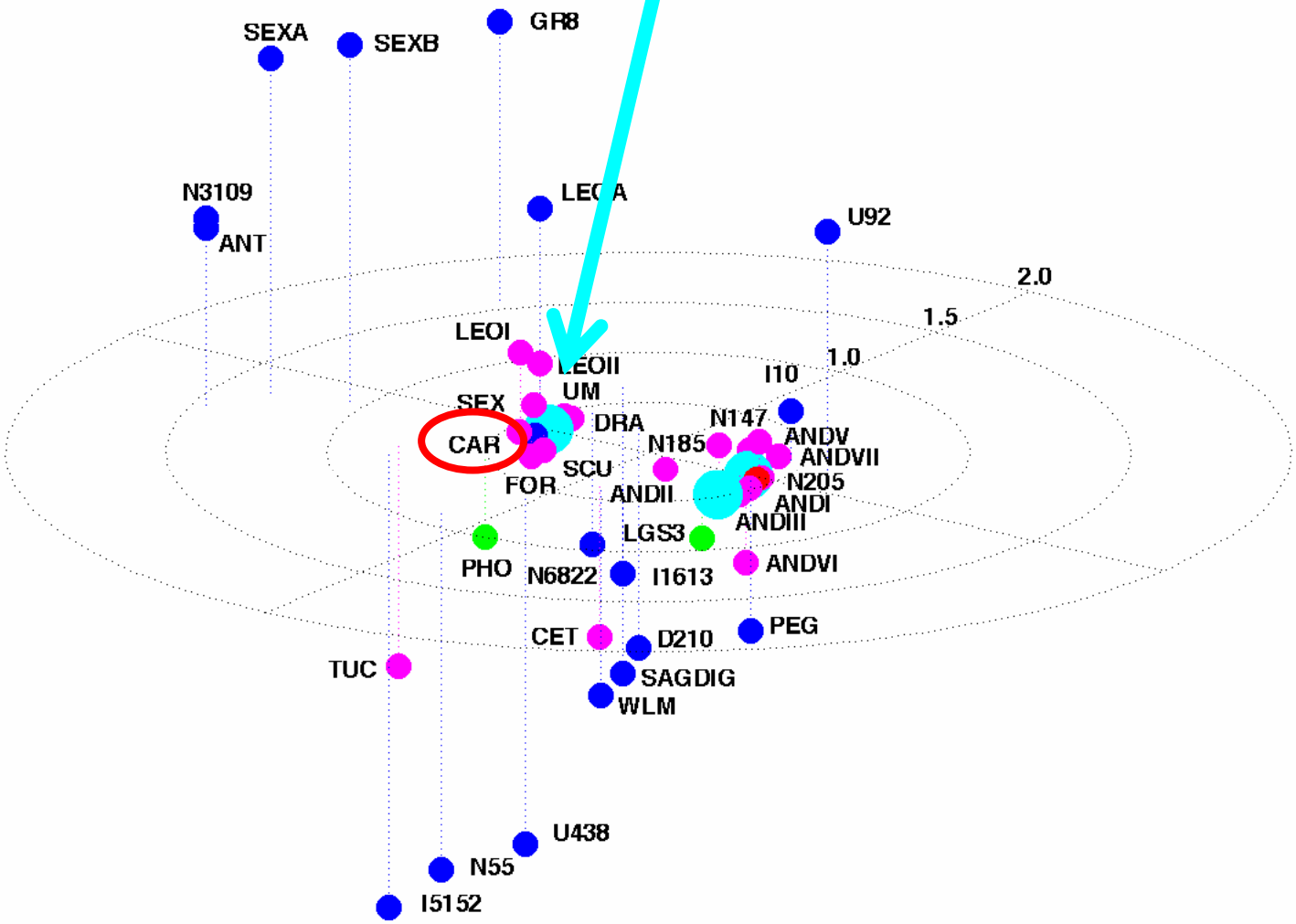
Munich, Jan 23-27, 2007

Stellar populations in the Local Group



The Carina dSph galaxy

- nearby $(m-M)_0 \sim 20.1$ ($\rightarrow$ D ~ 100Kpc)
- extended $R_{core} \sim 9'$; $R_{tidal} \sim 29'$
- low central density galaxy but high M/L ~ 30 s.u.
- complex SFH

The Carina Project: Long term, photometric and spetroscopic project aimed at studying the stellar content of the Carina dSph galaxy

- A.R. **Walker** *(CTIO)*
- R. **Buonanno** *(Univ. Roma Tor Vergata)*
- P.B. **Stetson** *(DAO)*
- H.A. **Smith** *(MSU)*
- M. **Dall'Ora**, V. **Ripepi** *(INAF-OA Capodimonte)*
- ***G. Bono***, C.E. **Corsi**, F. **Caputo**, L. **Pulone** *(INAF-OA Roma)*
- A. **Aparicio**, C. **Gallart** *(IAC)*
- ***M. Nonino*** *(INAF-OA Trieste)*
- ***F. Thévenin*** *(Nice Obs.)*
- ***P. Francois*** *(Paris Obs.)*
- S. Moehler *(ESO)*

Photometry: central region data set

Instr.	*f.o.v.*	*Filter*	*Tot.exp.*	*Date*
2.2m ESO	32′*x*33′	60 B	30,500s	5-7 Jan 2000
	0.23″/px	63 V	30,300s	
CTIO 4m	36′*x*36′	54 B	21,200s	19 Dec 1999
	0.27″/px	54 V	13,000s	8-9 Jan 2000
		22 U	22,000s	Dec 2004
		19 I	5,700s	Jan 2005

- Photometric reduction with DAOPHOT/ALLFRAME (Stetson 1987, 1994) → ~2,900 frames
- Development of authomatic procedures to extract the PSF

Results: color-magnitude diagram

~30000 stars (|sharp|<0.2)

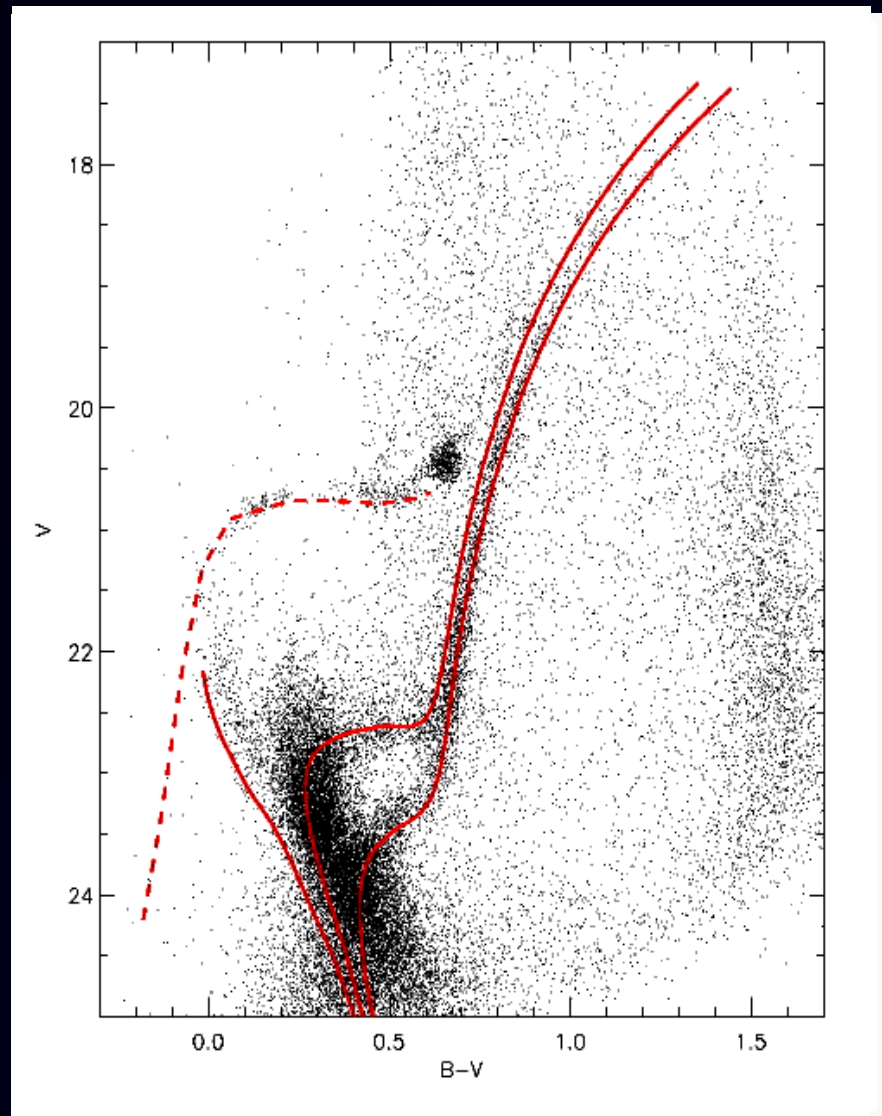
DM = 20.24
E(B-V) = 0.03
Z = 0.004 [Fe/H] = -1.7

→ isochrones superposition:

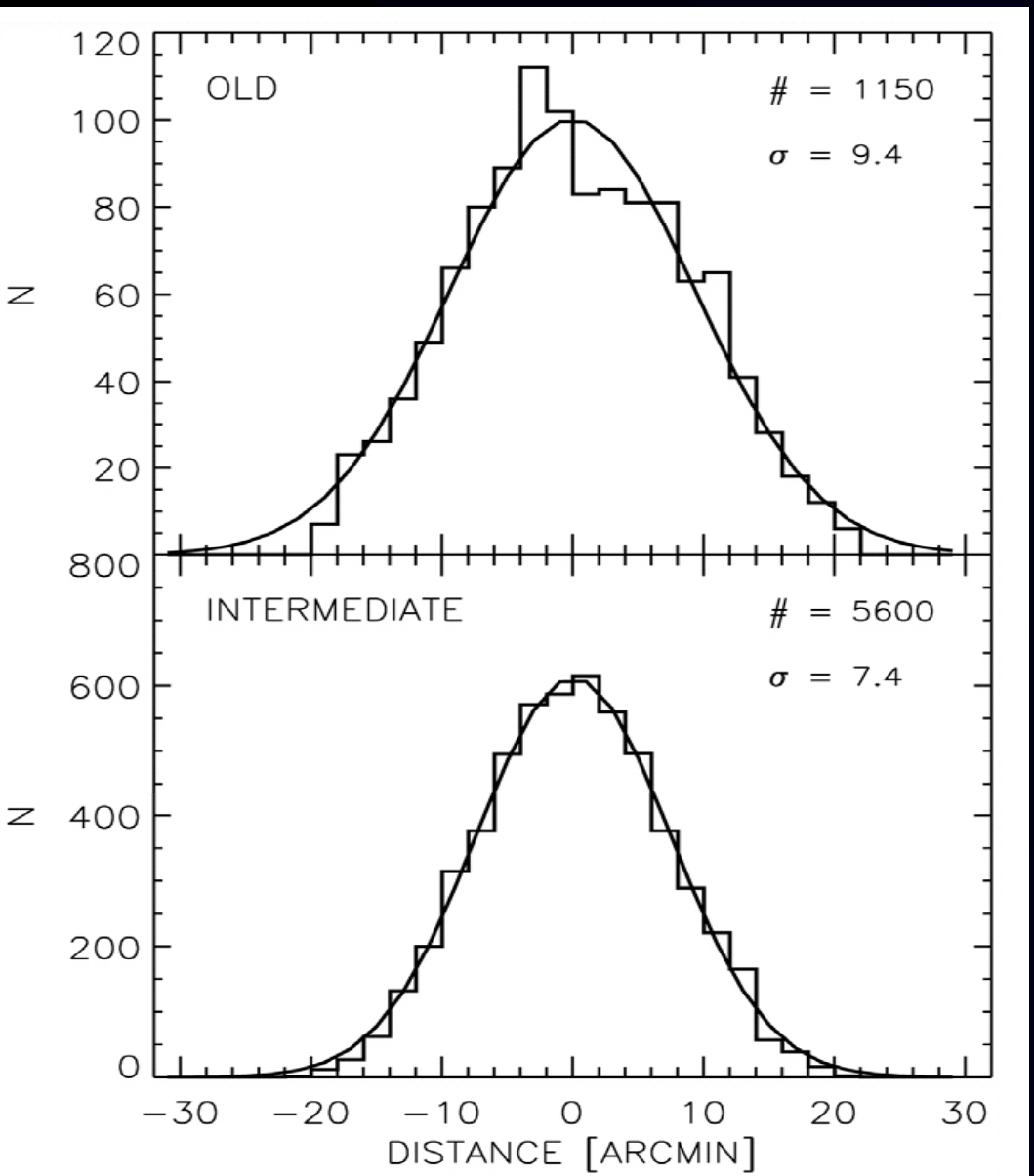
Old population ~11Gyr

Intermediate pop. ~3-7 Gyr

Young pop ~0.6-1 Gyr



Results: spatial distribution

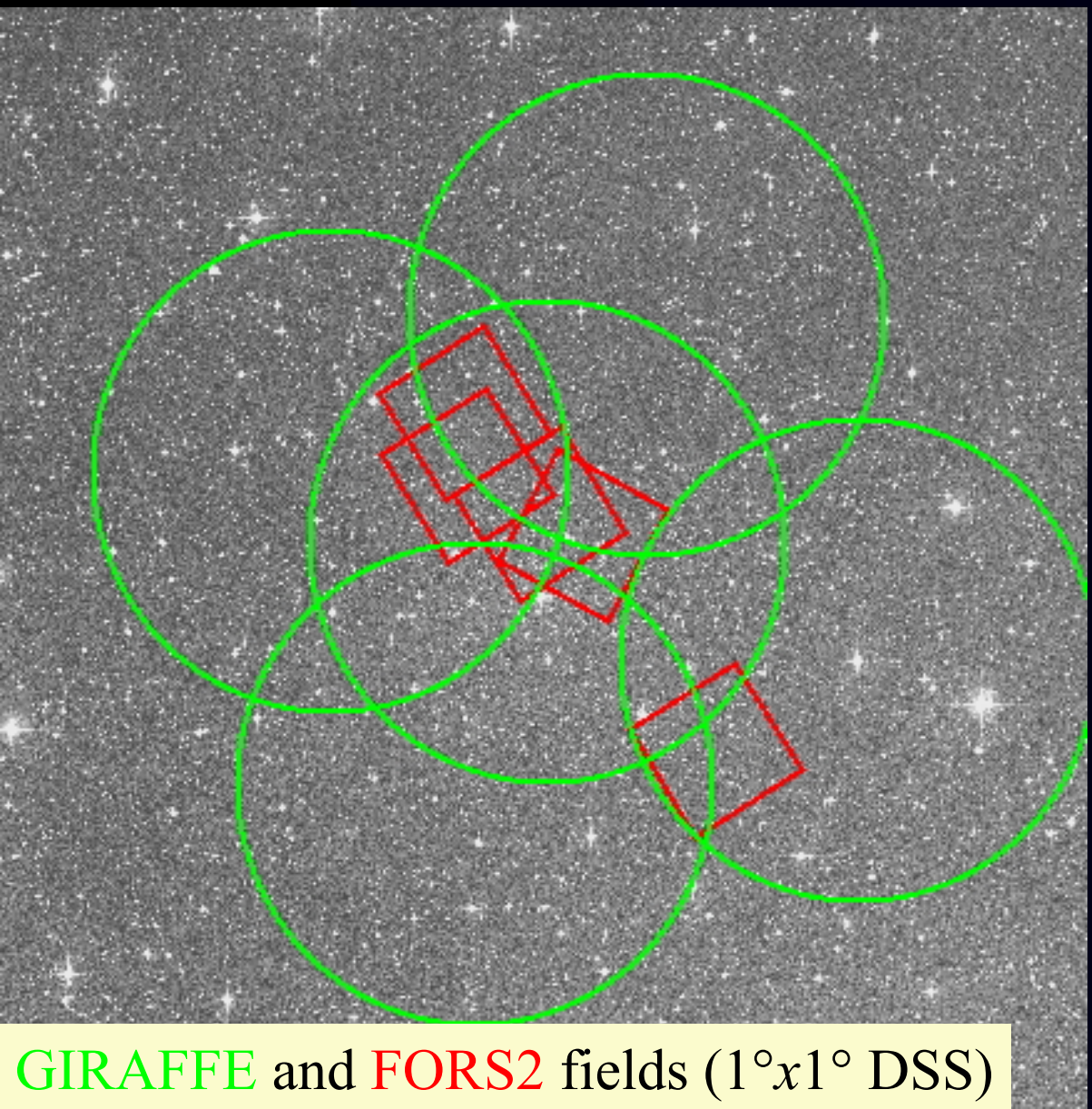


The intermediate-age stellar population is more *concentrated* toward the centre; old stars are distributed in a sort of diffused *halo*.
The peak of the distribution of the old stars is offset by ~2′.

Spectroscopy: data sets

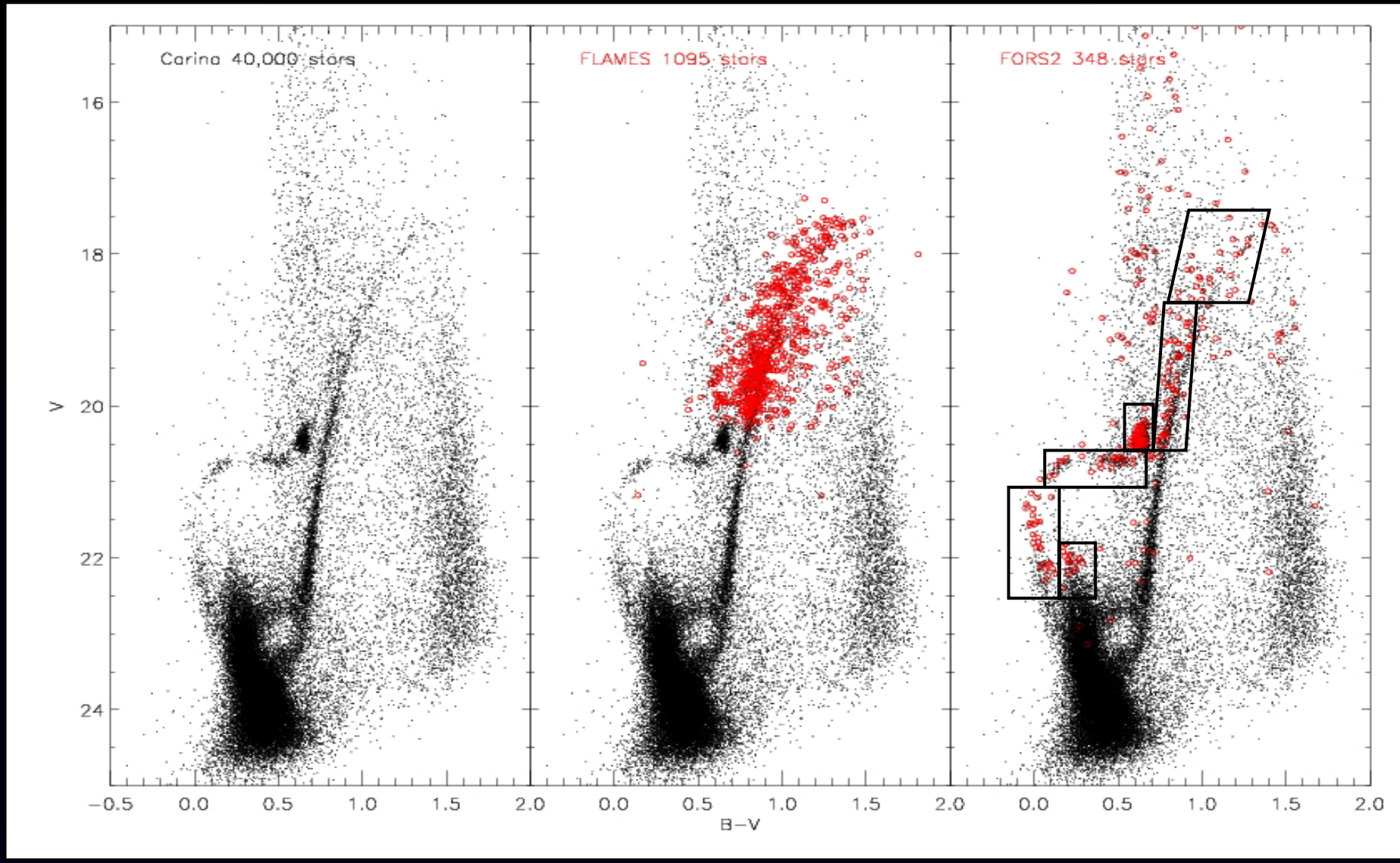
GIRAFFE	*RA*	*DEC*	*λ(nm)*	*exp time (hr)*	*tot # stars*	*note*
1	06:41:37	-50:57:58	LR8 820-940 (CaT) R~6500	18	1095 (RGB, AGB + Field)	ESO **archive** (171.B-0520) ------ Koch et al 2006 Martin et al 2006 Munoz et al 2006
2	06:41:00	-50:45:06		15		
3	06:42:51	-50:52:50		10		
4	06:39:50	-51:04:00		7.5		
5	06:42:05	-51:10:00		16		
FORS2						
A	06:42:03	-50:54:00	1028z (CaT) 773-930	2.6	348 (RGB,HB,MS, TO, variables + field)	072-D-0671 PI **Bono**; 076.B-0648, PI **Thevenin**; 078.B-0567, PI **Thevenin** (to be observed)
A	-	-	1400V 456-586 (Mg triplet) R~2000	2.9		
B	06:42:00	-50:50:30		2.9		
C	06:41:38	-50:55:34		5		
D	06:41:26	-51:57:30		2.9		
E	06:40:51	-51:07:56		1.3		

A sample of stars was selected from the FLAMES data base and observed with the 1028z FORS2 grism in order to have a direct comparison of both radial velocities and chemical composition obtained with the two instruments in similar spectral regions



GIRAFFE and FORS2 fields (1°*x*1° DSS)

The GIRAFFE data cover the Carina tidal radius. (~30')
We mapped the major axis up to the core radius (~10')



FLAMES (archive): based on EIS photometry (Koch et al. 2006)
FORS2: based on our photometry

Two main questions:

1) *Do the different populations present different kinematical properties?*

2) *Is there any spread in the chemical composition among different populations?*

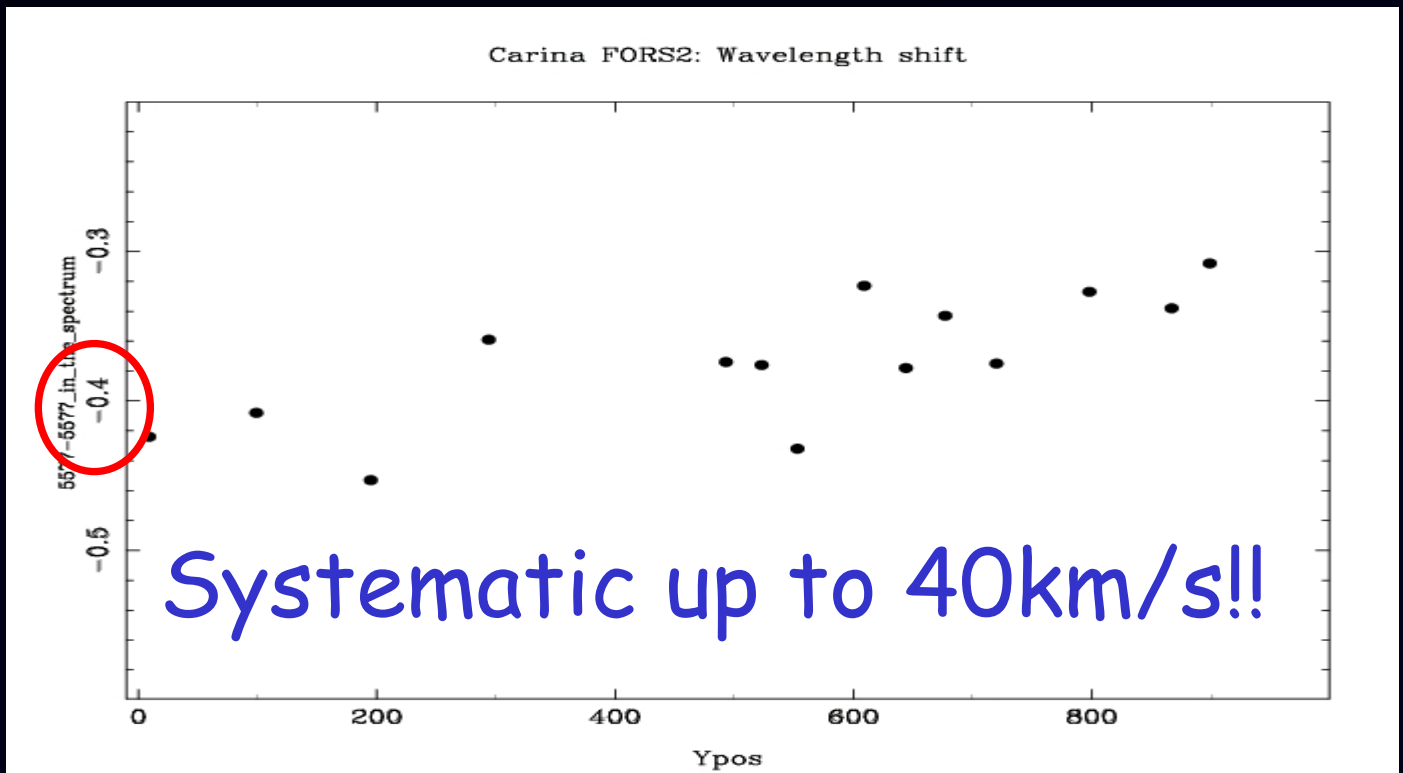
FORS2: data reduction

- IRAF environment;
- wavelength calibration obtained from the daytime lamps;
- radial velocity and chemical abundance from the stack of individual spectra

FORS2 critical points

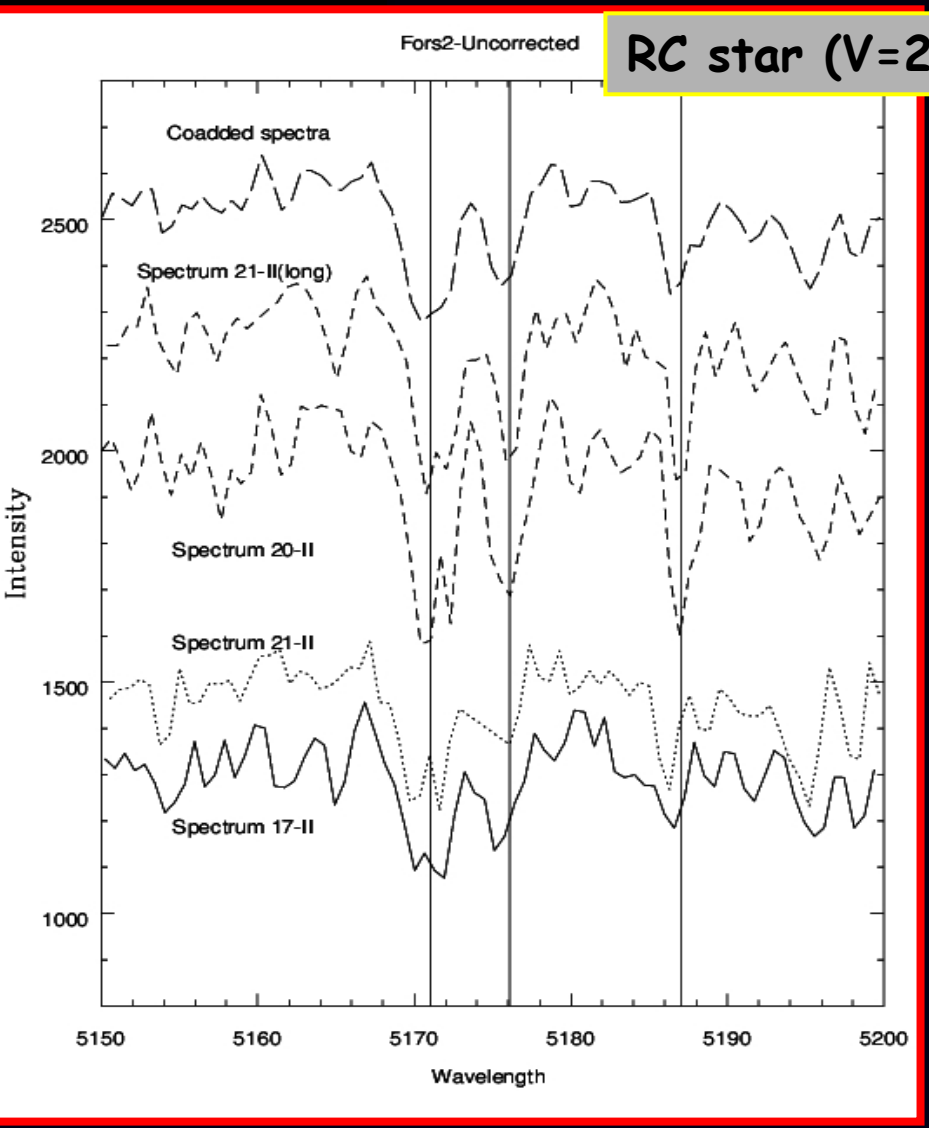
1) Positioning accuracy of the mask:

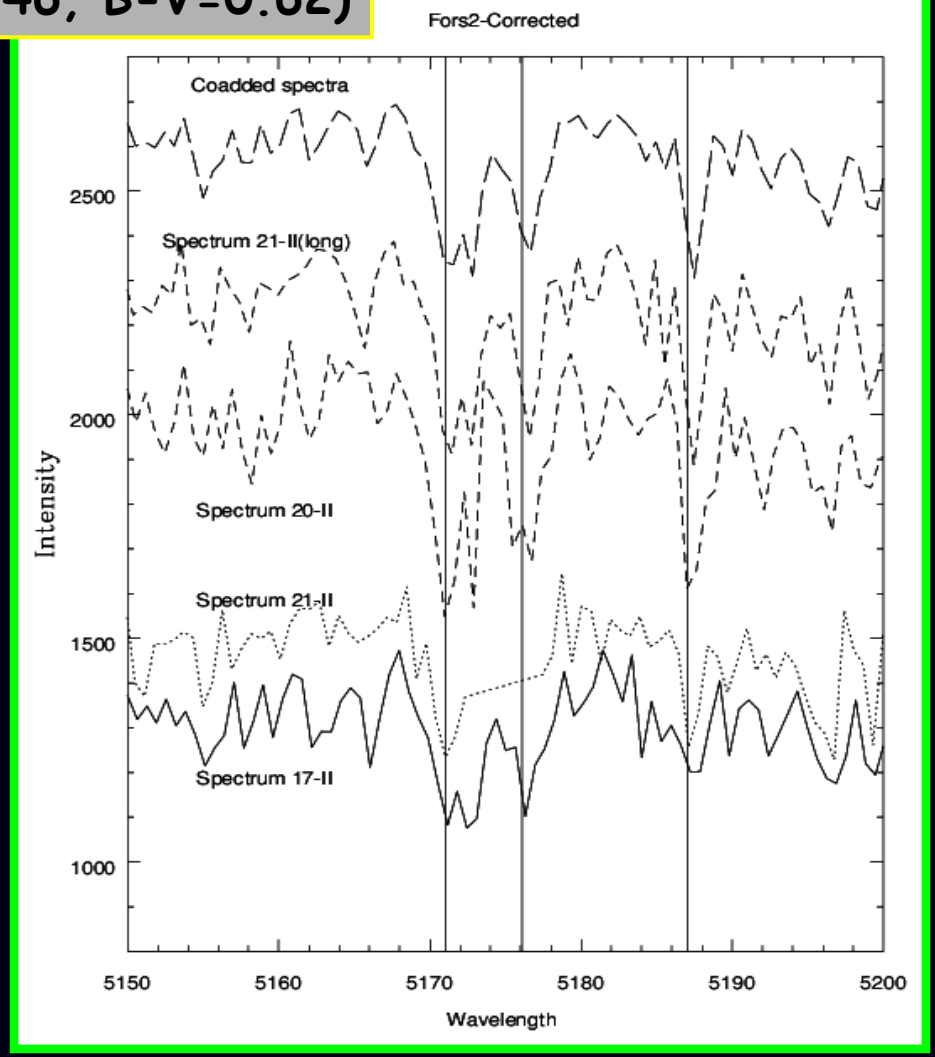
The same mask is placed (day-night calibration, different OBs) with an accuracy of 1 px (0.64Å for the 1400V grism)



Linear effect with the Y-coordinate of the slit along the chip, but Slope and zp are NOT constant !!

RC star (V=20.46, B-V=0.62)





Comparison between the stack of the uncorrected and corrected spectra. The lines of the Mg Triplet in the stacked corrected spectrum appear to be sharper and more centrally peaked when compared with the uncorrected spectra.

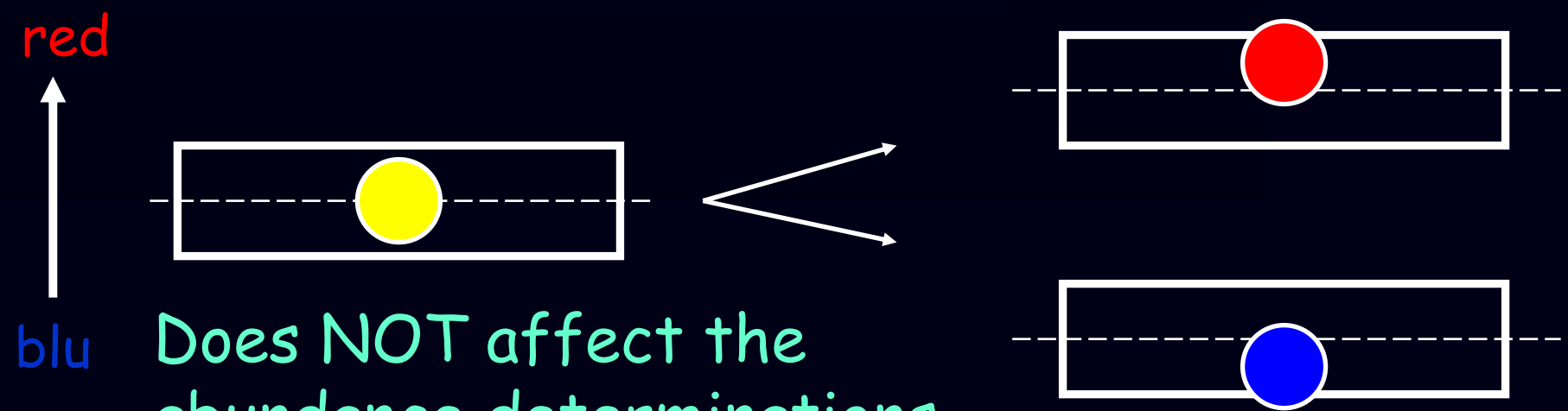
This effect has two major consequences:

*) The wavelength shift translates into a spread in the radial velocity determination of the order of 10-40 km/s on individual spectra (for the selected star, the difference between the corrected and uncorrected Vr estimate on the stacked spectrum is 14 Km/s)

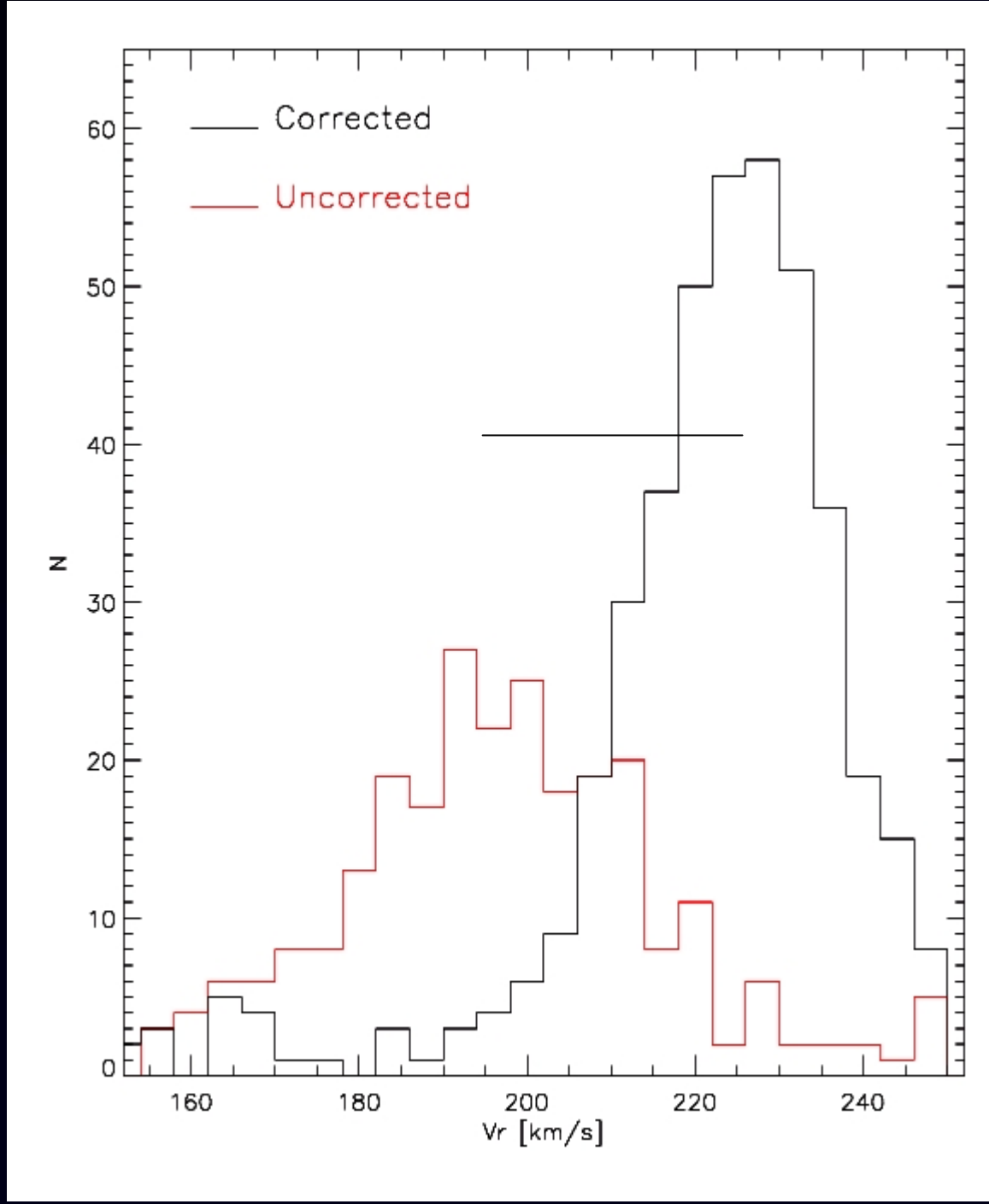
*) A broadening of the lines also implies an increase in equivalent width

FORS2 critical points

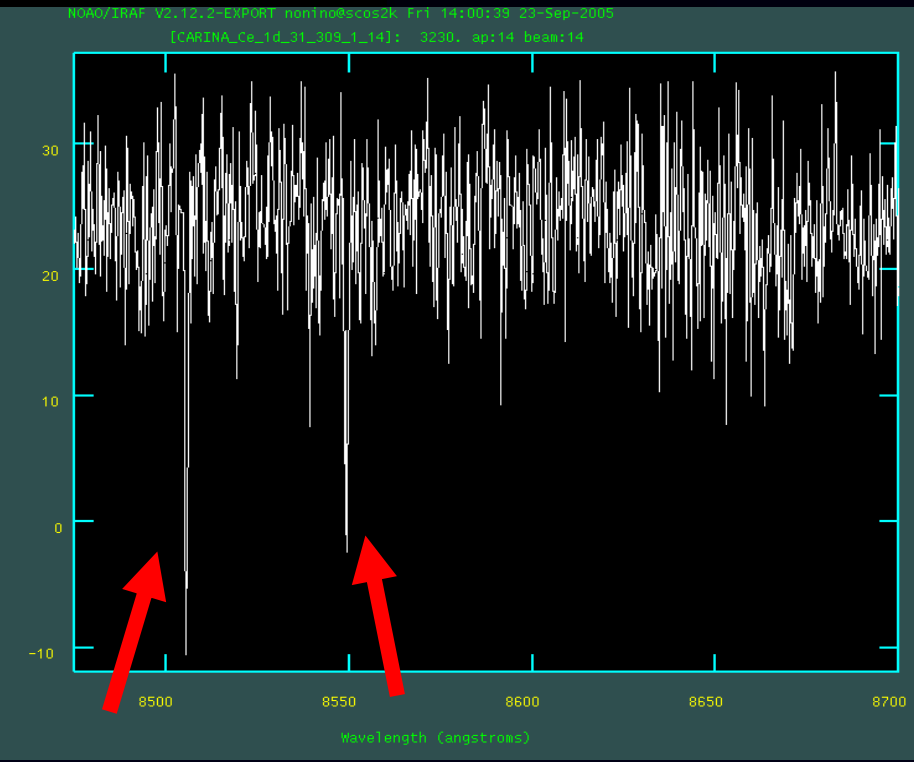
2) Position of the centroid inside the slit:
the star is not always placed in the center of the slit (while the sky IS) → the v_r can be under- or over-estimated according to the star centroid position (up to 20 km/s), due to the different optical path.

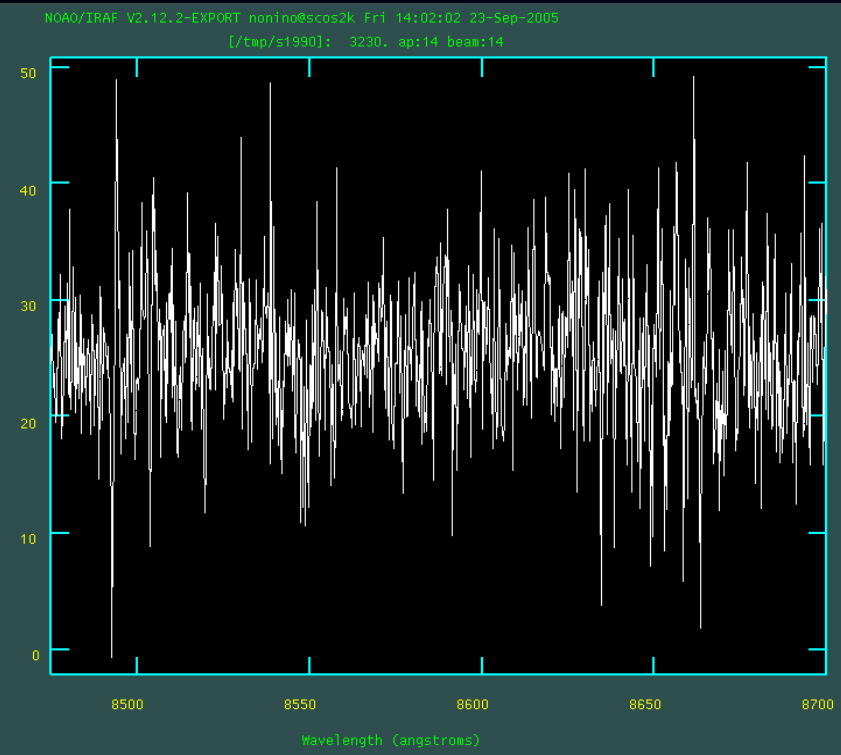


Does NOT affect the abundance determinations


Corrected
Uncorrected
N
0
10
20
30
40
50
60
160
180
200
220
240
Vr [km/s]

Flames critical points





SKY SUBTRACTION: misalignment between the sky lines measured in the sky fibre and in the stellar spectrum → non perfect sky subtraction → spurious features ($\Delta\lambda$ = 0.07Å, ~2.5 km/s)

Flames critical points

Uncorrect sky subraction:

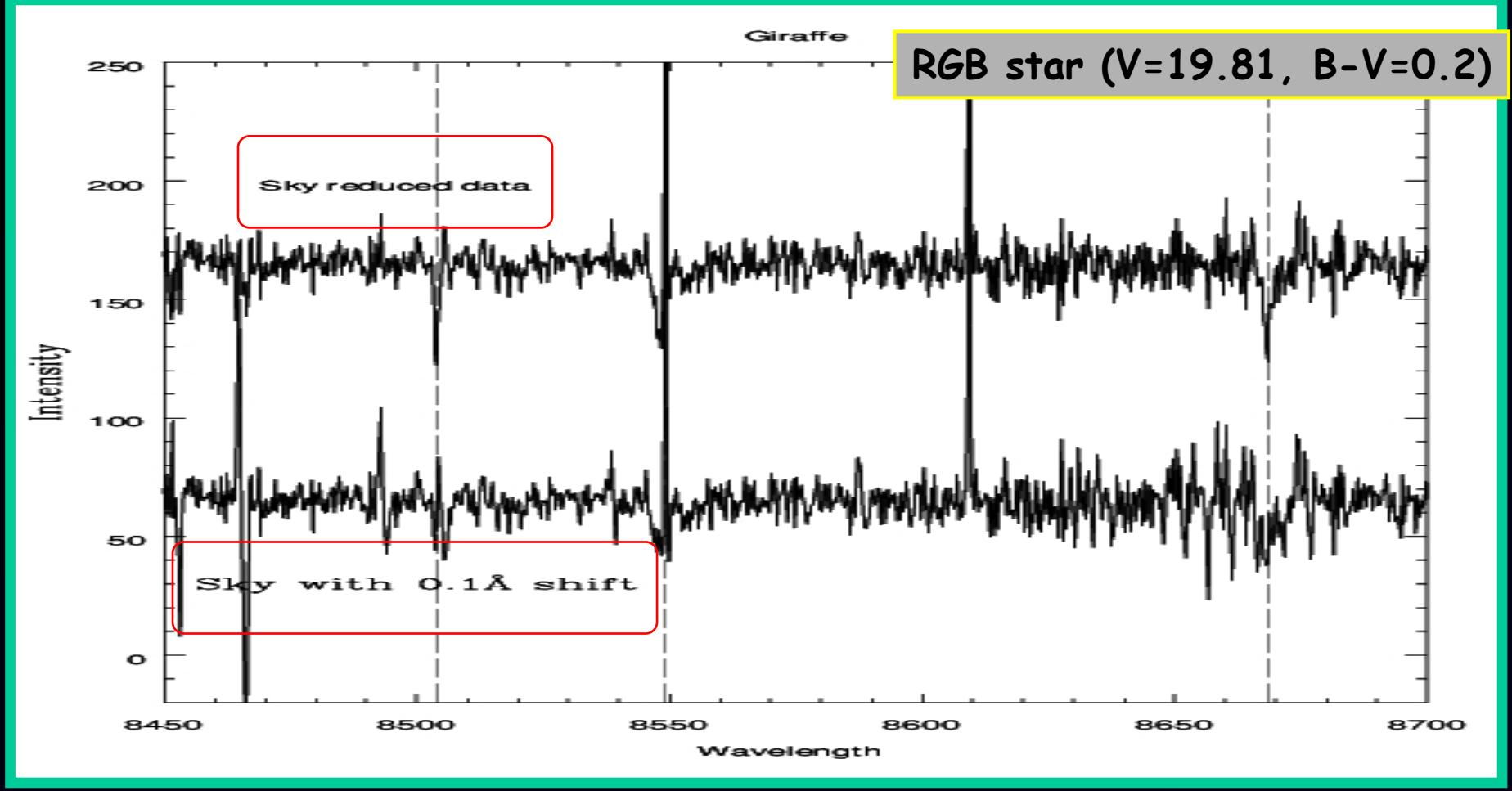
For each star, uncertainities are

→ *partially masked in the v_r determination*

but

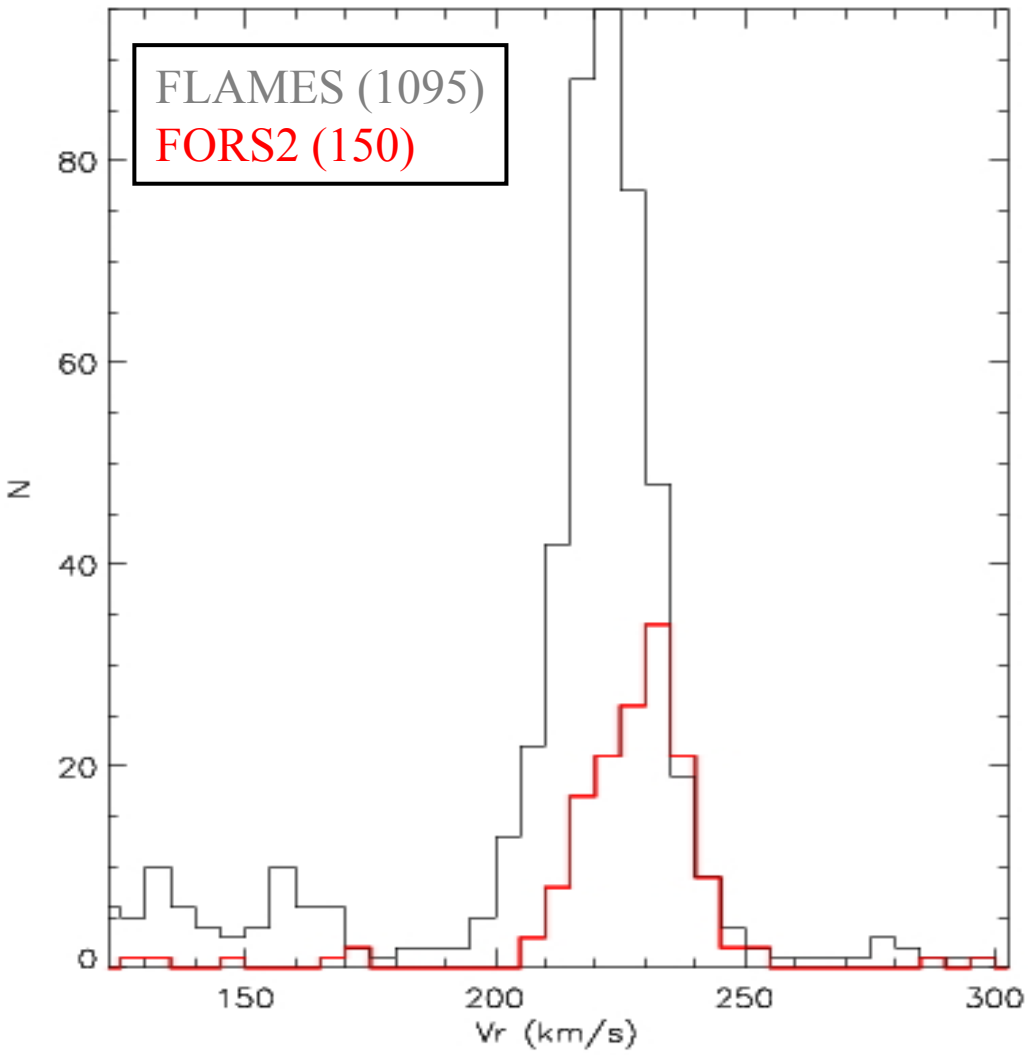
→ *show up in the **individual** abundance determination*

In particoular, the Carina radial velocity (~220km/s) moves the Ca triplet lines (8498, 8542, 8662Å) in corrispondence of sky emission lines (8505, 8549Å):
Ca(8498Å) → 8504 Å
Ca(8542Å) → 8548 Å



Altough the CaT lines appear quite different, the systematic shift in the radial velocity determination appears to be small (few km/s). However, the equivalent width of the lines at λ=8504Å and 8548Å changes by ~30%, from 0.62 and 1.49 to 0.45 and 0.98, respectively, being broader in the correct one.

First Comparison



Preliminary histogram of the radial velocity obtained from **FLAMES** and **FORS2** data sets. The peak velocity of the FORS2 sample (dominated by RC stars) appears to be shifted to higher velocities than the FLAMES sample (RGB stars). This result, although preliminar, appears very interesting. However, a more detailed investigation is mandatory to unveil possibile subtle systematic effects.

Conclusions

- ✓ complex SFH in the Carina dSph galaxy;
- ✓ different radial distribution for the old and intermediate-age populations;
- ✓ we collected FORS2 low-resolution spectra for ~350 stars of different populations in the Carina dSph galaxy and we analyzed ~1,100 mid-res. spectra from the GIRAFFE archive;
- ✓ the sky subtraction plays a major role to determine accurate chemical abundances with GIRAFFE;
- ✓ the positioning of the mask and the position of the centroid of the star inside the slit can introduce errors in the radial velocity up to 50 km/s.

Future developments

- complete the analysis
  chemical abundances;
- verify the metallicity s
  populations, if any (Ca,
- verify the kinematical
  populations;
- direct comparison with
- extra-tidal stars?