A MOS@E-ELT to constrain kinematics and chemical evolution of nearby dwarf galaxies.

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Abstract. Multi-object spectrographs (MOS) available at the 10m class telescopes disclosed a new scenario concerning the structure and the evolution of nearby dwarf galaxies. They typically display a broad metallicity distribution, suggesting that the environment plays a key role in the chemical evolution of these flabby stellar systems. Moreover, there is evidence that dwarf galaxies show a complex kinematic structure probably reminiscent either of a disk or of a bulge. We present preliminary results concerning the Carina kinematic structure. We are using a very large data set of homogeneous radial velocity measurements covering the entire body of the galaxy. We found a clear evidence of a rotational pattern in this system. Together with the kinematical discussion, we show the accurate iron abundances for a sizable sample of red giants in the Carina based on spectra collected with UVES at ESO/VLT. The opportunity to collect data with a MOS@E-ELT for a sizable sample of stars with deep magnitudes (22-25) will allow us for the first time to investigate the chemical composition of unresolved (main sequence) and minimally (subgiant) evolved stars in several nearby galaxies. We present simulations concerning selected dSph and dIrr.

Introduction. The Local Group (LG) is a fundamental laboratory to constrain galaxy formation and evolution. Carina (dSph) stands out among LG galaxies for its Star Formation (SF) activity extended over more than 1 Gyr. Deep and accurate photometry disclosed that Carina experienced at least three SF episodes with ages of 2, 3-6 and 11-13 Gyr (Mighell 1990; Smoker-Shane et al. 1996; Hernandez et al. 2000; Rizzi et al. 2003; Monelli et al. 2003, Bono et al. 2010). Moreover, Carina shows a complex kinematic structure, as suggested by Fabrizio et al. (2011), with evidence of substructures with transition properties. In this context, Carina is a cornerstone for the future instruments available at the E-ELT, and in particular for the multi-object spectrographs. Indeed, we undertook a detailed spectroscopic analysis of Carina stars using low, medium and high resolution spectra to provide homogeneous measurements of iron and alpha-element abundances and to constrain the kinematic properties of the different subpopulations.

Fig. 1. The use of several multi-object spectrographs available at 10m class telescopes allowed us to assemble a large dataset of spectroscopic targets that covets the entire body of the Carina dwarf galaxy. In particular, we used archival and proprietary data for UVES (R=48000), GIRAFFE (R=30000, LR=6000) and FORS2 (R=6800) at the ESOTUV, complemented by data from MAMM at the Magellan (R=24000, Walker et al. 2007). We ended up with a total sample of ~2590 stars, with an accurate measure of radial velocity (RV; Fabrizio et al. 2011), identifying ~1735 Carina candidate stars (RV>200 km s$^{-1}$). In this figure, RV colors and magnitude diagrams are plotted, with the labeled color coding, the various spectroscopic targets belonging to Carina.

Fig. 2. The entire spectroscopic sample (see fig.1), based over more than 1736 Carina candidate stars, allowed us to analyze the mean RV (top) and the dispersion (bottom) as a function of the age of the star. Different color-coded lines are related to different ages, from 0 to 15 Gyr. In this plot, we are facing with a rotational pattern, with an amplitude of ~3 km s$^{-1}$ + More interesting is the fact that there is a transition in the interior/mode, inside the core radius (R<1 Gyr) it is noteworthy that the ratio between the rotation velocity and the dispersion is of the order of few tenths, suggesting that Carina is a system gas pressure supported, though it shows a transition (Fabrizio et al. 2013, in prep.).

Conclusions. Top level requirements for MOS@E-ELT

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<tr>
<th>Large Field</th>
<th>3.5&quot;x(10’18&quot;)</th>
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<tr>
<td>Target density</td>
<td>10 arcmin$^2$</td>
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<tr>
<td>Spatial resolution</td>
<td>GLAO</td>
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<td>Spectral resolution</td>
<td>&gt;3000 – 20000</td>
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<td>Magnitude coverage</td>
<td>1.0 – 2.2 µm</td>
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<td>Limiting magnitude</td>
<td>J, H, K &lt; 25 mag</td>
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<td>S/N</td>
<td>~30 (dim) – 60 (abund)</td>
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<td>Simultaneous multiplicity between</td>
<td>low/medium and high resolution fibers</td>
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Fig. 3. We used the high-resolution spectra collected with UVES (see fig.1) to obtain accurate iron abundance measurements for 44 red giants in the Carina dSph galaxy. The figure here shows the metallicity distributions of Carina stars based on low (top) and high (bottom) lines. The original means and the weighted standard deviations are labelled, together with the sample size. We found that the range in iron abundances covered by Carina RGs (~1 dex) agrees quite well with similar estimates based on high-resolution spectra (e.g. Lemasle et al. 2012). However, it is a factor of two smaller than abundance estimates based on the near IR Call turtle (Koch et al. 2006). Moreover, for the stars for which we measured both Fe and Fe abundances we found evidence of NTE effects between strongly and weakly ionized iron abundances (more details in Fabrizio et al. 2012).

Fig. 4. We also performed a theoretical experiment to understand the limit of MOS@E-ELT, extending our analysis beyond the Local Group. As set of benchmarks (from Tucano-BaSTI database, Pietrinferni et al. 2006) in the K vs J - CMD, we identified a system with a similar formation history. We showed that the oldest population at ~12 Gyr, an intermediate-age population at ~1 Gyr, and a young population in a range of 30-60 Myr. We applied a distance modulus of the order of Virgo or Fornax clusters, and we found that, by selecting a limiting magnitude of -25 (mag), we would have access to the brightest portion of the RGBs. This means that we can obtain important constraints on the kinematics and abundances of these stellar systems. Furthermore, we indicate the same limiting magnitude distribution for other dwarf galaxies (e.g., NGC300 or Sculptor group). In this case, the capabilities of E-ELT will allow us to obtain spectroscopic measurements for the entire extensions of RGB and young MS, while, for the closer ones, we also have the opportunity to investigate the HB stars.