First Images with the ARGUS Mode of FLAMES

The commissioning of the large Integral Field Unit ARGUS of the VLT instrument FLAMES has successfully been completed. The capabilities of this new instrument mode together with some first scientific test images are presented.

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An increasing number of the current and future instruments of the VLT are equipped with Integral Field Units (IFUs). FLAMES, the multi-fibre facility at the VLT (Pasquini et al. 2002), is no exception and provides two different types of IFUs. Each of the two plates of the Fibre Positioner OzPOz hosts 15 deployable mini-IFUs of 2×3 arcsec^2 aperture, while a larger, stationary IFU named ARGUS is mounted at the centre of Plate 2.

All FLAMES IFUs have been developed in collaboration with the Observatoire de Paris-Meudon (Jocou et al. 2000). For technical reasons, the commissioning of ARGUS was postponed from Period 70 to Period 71 and the facility will be offered to the community starting on October 2003. While all potential users are invited to read the public Commissioning Report[1] which includes a detailed technical description of ARGUS, in this *Messenger* article we would like to share some of the spectacular test images of the Homunculus nebula around the Luminous Blue Variable η Carinae, obtained during the ARGUS commissioning nights in July 2003.

The ARGUS Integral Field Unit

With ARGUS in the focal plane of the VLT, the light of the astronomical target is collected by a rectangular array of 22×14 square microlenses, each of 0.52×0.52 arcsec^2 in size. The light from the microlenses is re-arranged along the GIRAFFE spectrograph slit through optical fibres, so that on the GIRAFFE detector, 300 separate fibre spectra are formed, grouped into 15 subslits of 20 fibres each. The microlens output has been organised on the GIRAFFE slit in such a way so that two adjacent microlenses on the sky correspond to adjacent fibre spectra on the detector. With respect to other integral field units existing or planned at the VLT, ARGUS has the unique capability of coupling spatial resolution with a fairly high spectral resolving power of about 11,000 and 33,000 with the low and high resolution gratings of GIRAFFE, respectively.

The First Spectra

Figure 1 shows a portion of a spectacular ARGUS spectrum of one equatorial region of the η Carinae Homunculus nebula, taken using the GIRAFFE high-resolution setting around the Hα line (HR14, which has a resolving power of R=47,000 and a wavelength coverage of 638–663 nm). The dispersion is along the horizontal axis, with the wavelength increasing from left to right; the 300 single fibre spectra are displaced along the vertical axis. The three nebular emission lines of [NII]6548, Hα, and [NII]6583 are clearly visible.

This raw frame already contains quite a lot of information: in particular the elliptical and cross-shaped outlines of the three emission lines on the CCD are striking. The particular shapes are caused by two effects: first we can clearly see for the

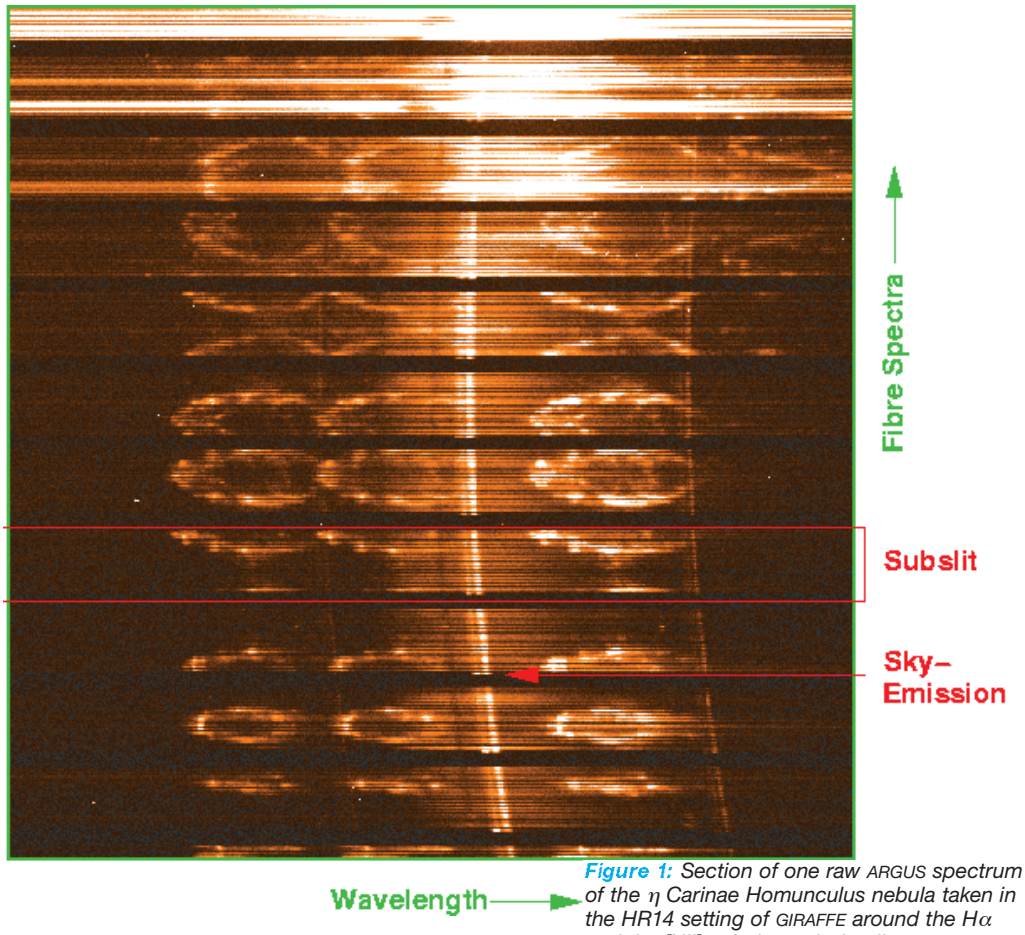

Figure 1: *Section of one raw ARGUS spectrum of the η Carinae Homunculus nebula taken in the HR14 setting of GIRAFFE around the Hα and the [NII] nebular emission lines.*

[1]http://www.eso.org/instruments/flames/manuals/ArgusCommissioning.pdf

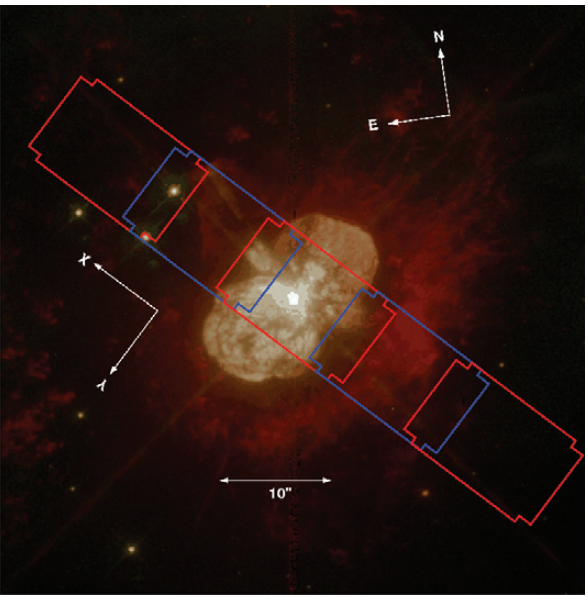

Figure 2: *Position of the five ARGUS pointings on the η Carinae Homunculus nebula superimposed on a HST WFPC-2 image (from HST press release STSCI-1994-09).*

same spatial point one gas component receding and one approaching: in fact, for a given fibre spectrum, two emission lines per ionisation stage are present, one red and one blue shifted with respect to the unshifted position of the line; this observation indicates that we are looking at an expanding thin shell of the nebula. The second effect, which causes the roundish shape, is that within one subslit, adjacent fibre spectra also correspond to adjacent spatial regions. Their continuity on the sky and on the detector results in a smooth transition from one spectrum to the next. However, this continuity is not provided from subslit to subslit because some subslits have been mounted with the fibres in reverse order on the GIRAFFE ARGUS slit.

Spectra from five overlapping pointings were acquired along the equatorial axis of the η Carinae Homunculus nebula. A superposition of the ARGUS apertures and their orientations onto an HST image of the Homunculus is shown in Figure 2. All spectra were taken in the HR14 setup with an exposure time of 300 seconds each, except for the pointing on the central (brightest) region of the nebula where the exposure time had to be reduced to 1 second to avoid saturation of the Hα line. Like all FLAMES commissioning data, these first ARGUS observations will be made publicly available to the ESO community through the ESO archive.

Each of the ARGUS frames contains both spectral and spatial information which is best stored in a data cube with one spectral and two spatial dimensions. Two-dimensional slices can easily be extracted from such a data cube for presentation and data analyses. An example of such a data cube is given in Figure 3, where all five η Carinae frames have been assembled to form one data cube. The data cube is organised in such a way that the axis at the base of the cube is in wavelength, while the second is along the X direction as indicated in Figure 2 (i.e., the long side of the mosaic). The height of the cube is along the Y-axis. Therefore, looking at each wavelength X-plane is equivalent to a longslit spectrum of 40 arcsec length with a spatial resolution of 0.52 arcsecs. A total of 14 of these planes exist along the Y axis, each corresponding to one microlens row along the short side of ARGUS. Out of the 14 slices, only four are shown in Figure 3. The discontinuity in the middle of each plane is caused by the fact that the central part is created from the shorter 1 second exposure. The four slices presented cover a small spatial area of 6 arcsec in the Y direction and reveal the complex spatial and dynamical structure of this part of the Homunculus nebula. At the same time, the simultaneous observation of three different nebular emission lines will allow the study of the physical conditions in great detail.

From our first experience with the ARGUS integral field mode of FLAMES at the VLT, we conclude that the comparatively large field of view and the spatial sampling of the ARGUS-IFU, paired with the high resolution of the GIRAFFE spectrograph, indeed provides the ESO community with a unique facility that will lead to many new exciting observing opportunities.

Acknowledgements

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References

Pasquini, L., et al., 2002, Installation and Commissioning of Flames, the VLT Multifibre Facility, *ESO Messenger* 110, 1

Jocou, L., Guinouard, I., Hammer, F. , Lenoir, H., 2000, Development of four multifiber links for the Flames project, *SPIE* 4008, 475

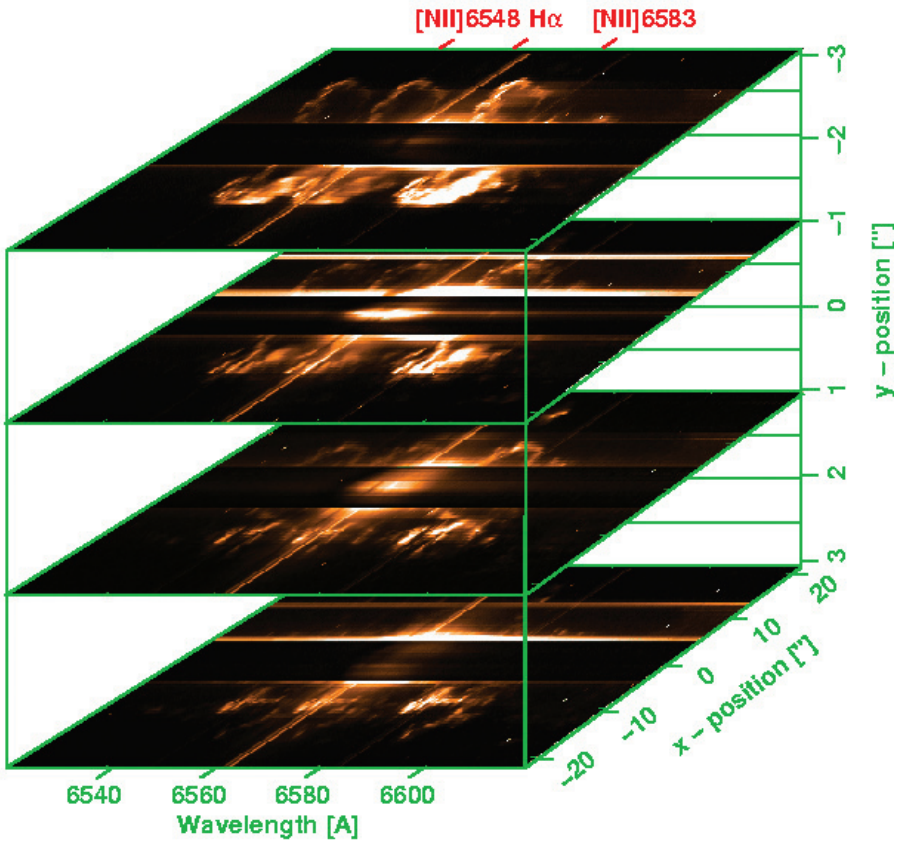

Figure 3: *Four out of 14 slices from the η Carinae ARGUS data cube around the Hα and the [NII] lines. The horizontal lines at the back indicate the positions of the 10 slices which could not be shown.*