Physical properties of stellar populations in the host galaxy of GRB 100316D obtained with MUSE

L. Izzo, C.C.Thöne, S. Schulze, on behalf of a larger collaboration

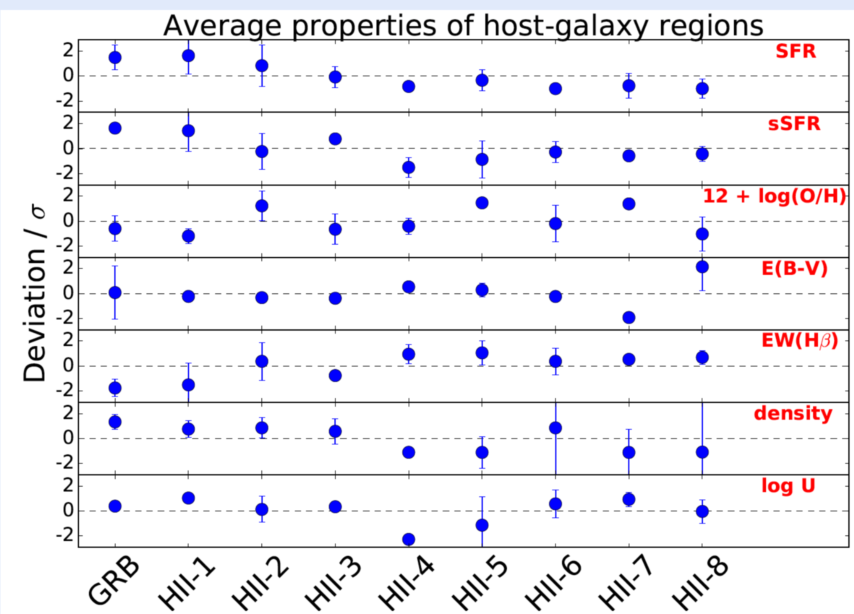
Motivations

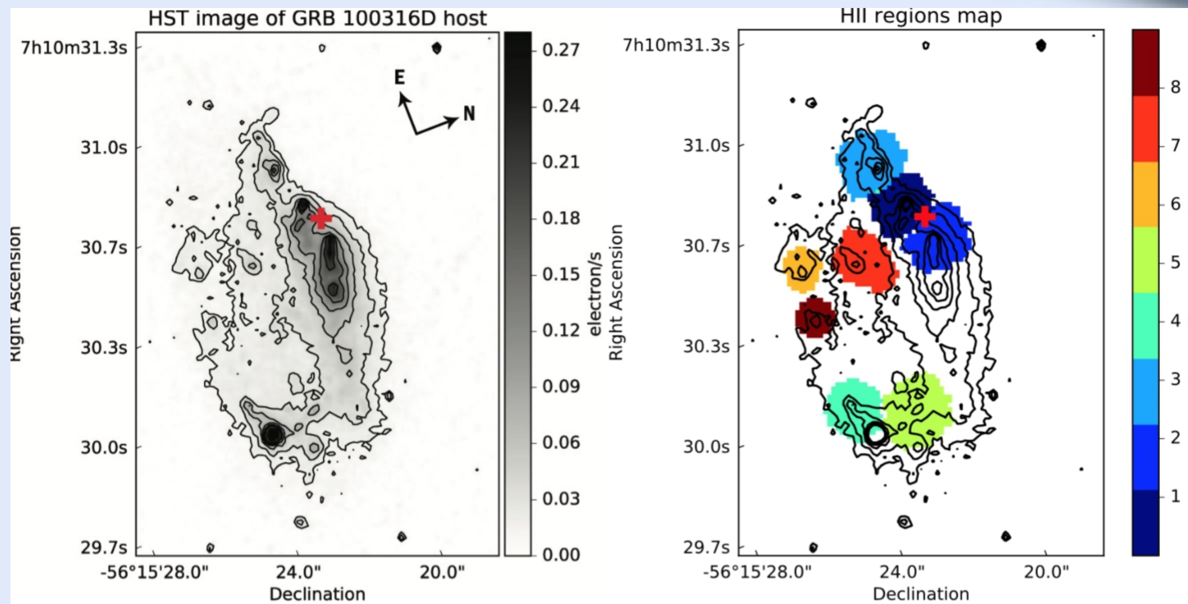
- *most nearby GRB-SN (z=0.059)*
- *bright extended host galaxy*
- *disturbed morphology (HST)*

Perfect target for MUSE !!!

Spatial-resolved properties

-> 8 HII regions identified + 1 GRB region





A possible runaway progenitor star ?

- *offset between GRB and HII-1 region = 660 pc*
- *age from Hbeta EW = 20-30 Myr*

kick velocity > 30 km/s

in agreement with expected values for runaway stars ejected
1) in binary SN explosions
2) during process of star-formation

For more galaxy maps and results see also C.C. Thöne talk and arXiv:1704.05509

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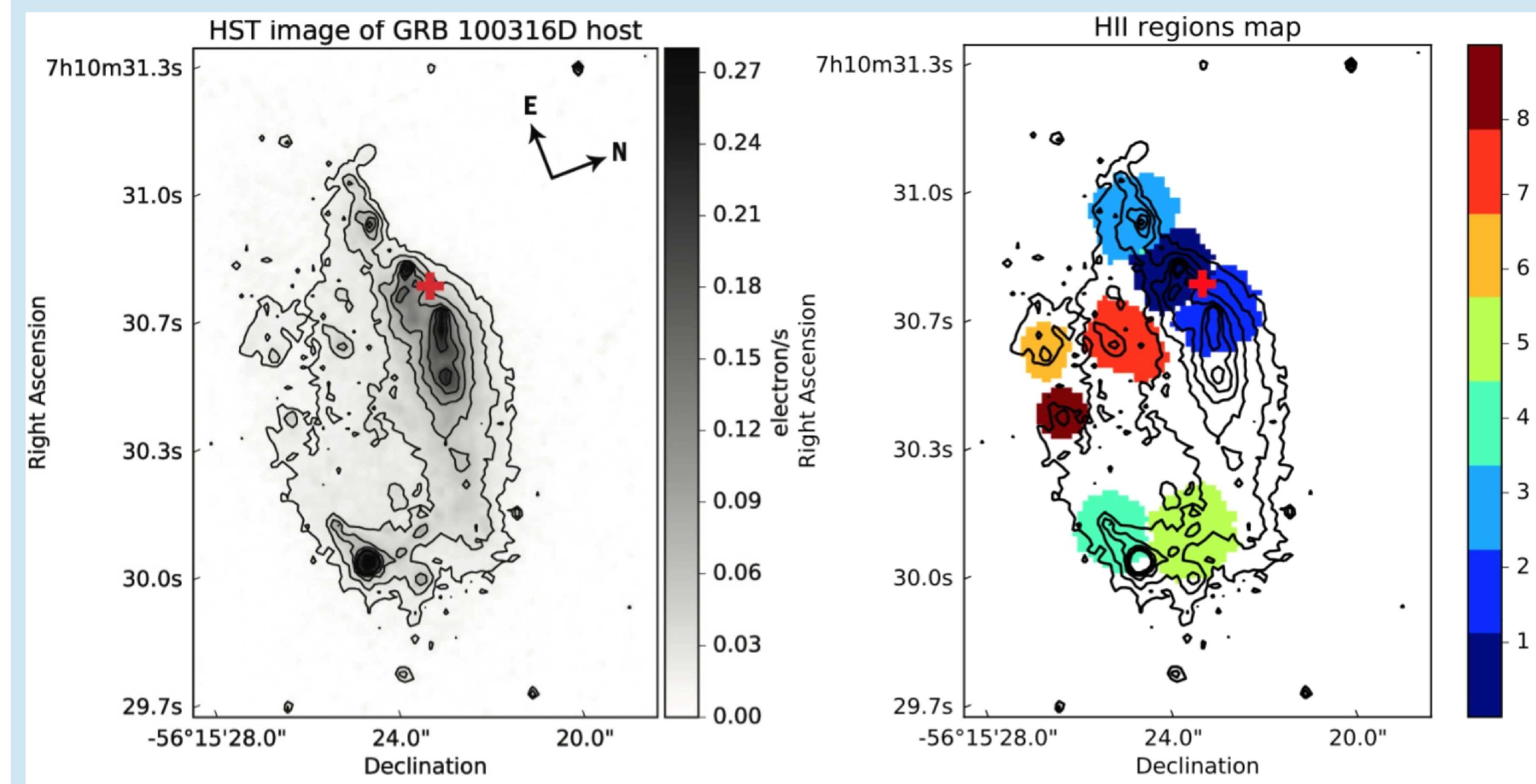
Motivations

While the properties of most SNe associated with GRBs are very similar to those of the prototype SN 1998bw, the properties of the GRB itself show a rich diversity, such as burst durations between 2 and >10000 s and an isotropic gamma-ray luminosity between 10^{46} and > 10^{52} erg/s. To explain this observed diversity, an important role can be played by the jet originating the gamma-ray emission: high-luminosity GRBs with Liso >$10^{49.5}$ erg/s are powered by collimated ultra-relativistic jets that successfully penetrate the stellar envelope, whereas a weak jet is either chocked or barely manages to penetrate the stellar envelope (Bromberg et al. 2011). These distinct interpretations and the different rates for low- and high-L GRBs suggested that the two sub-classes are connected to distinct populations of massive stars.

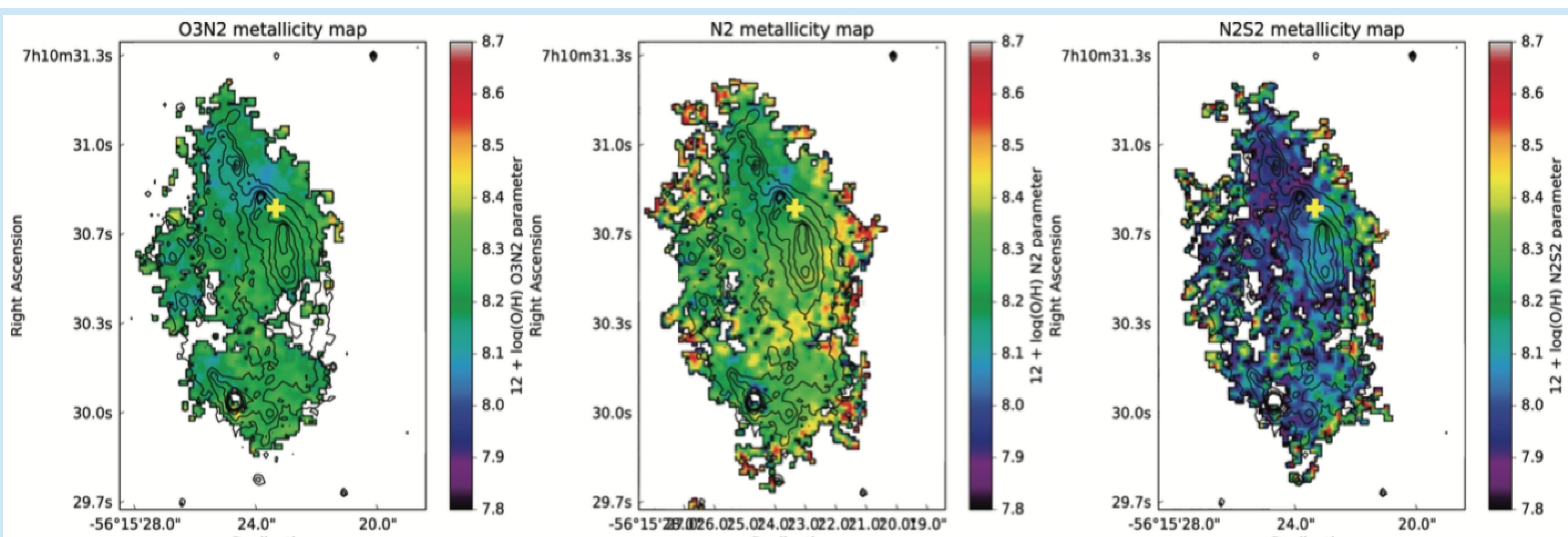
We used MUSE to investigate the immediate GRB environment at high spatial resolution to obtain accurate information on the physical properties of the region where the GRB progenitor spent its entire evolution (Modjaz, 2011) and comparing these properties to other star-forming regions in the host galaxy.

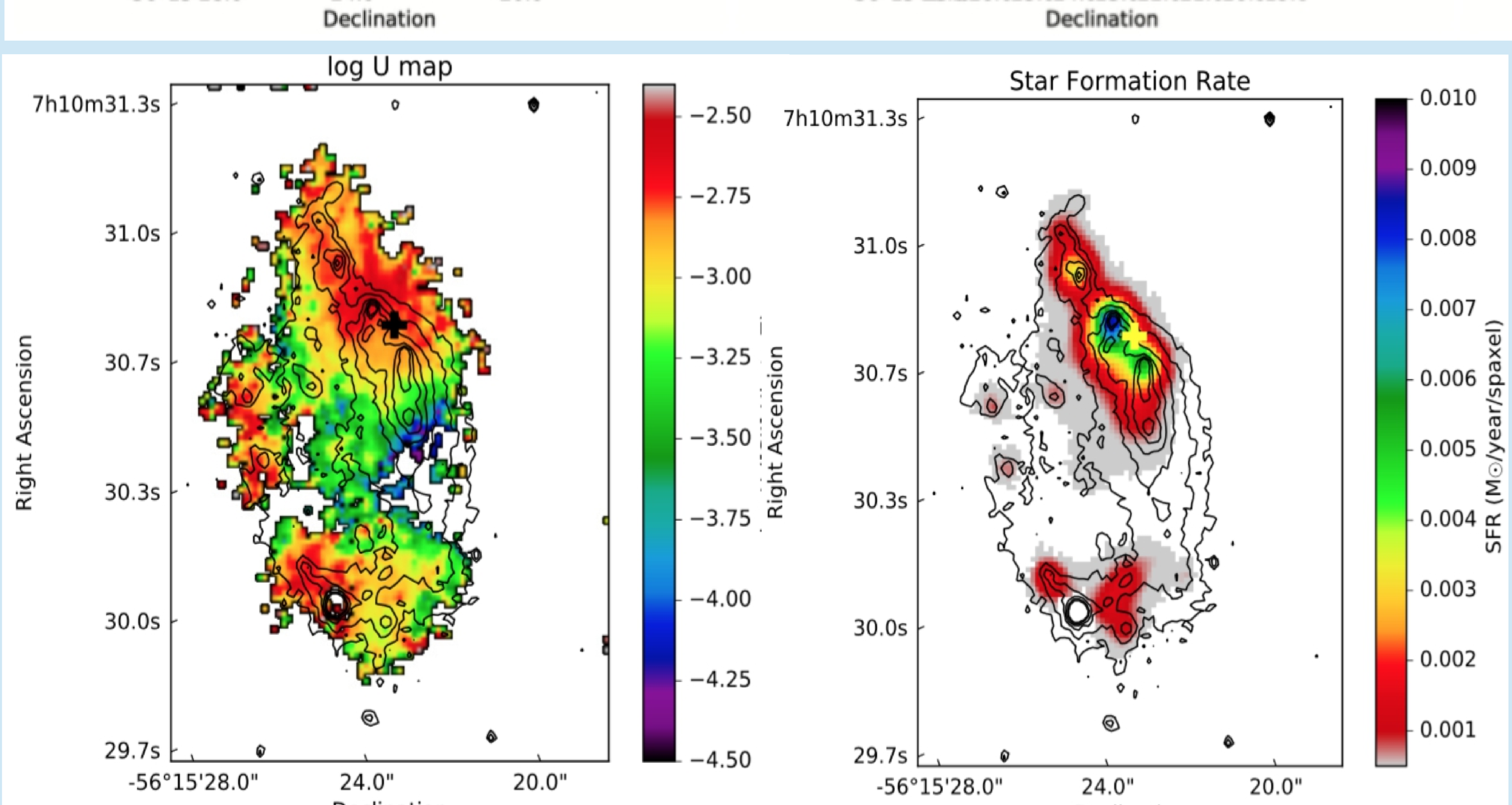
GRB 100316D was a low-luminosity burst associated with the SN 2010bh (Olivares et al. 2012, Bufano et al. 2012) and characterized by the presence of a possible thermal component in its X-ray emission (Starling et al. 2011). The host galaxy of GRB 100316D is a blue galaxy with an extended (diameter ~ 12 arcsec) and disturbed morphology. Imaging obtained with the HST shows the presence of a large number of giant HII regions with the GRB located close to the brightest of these knots. We identified individual HII regions in the galaxy using an algorithm that automatically identifies regions in the Ha map with 1) a luminosity larger than 10^{38} erg/s; and 2) a maximum size of 1 kpc for each region.

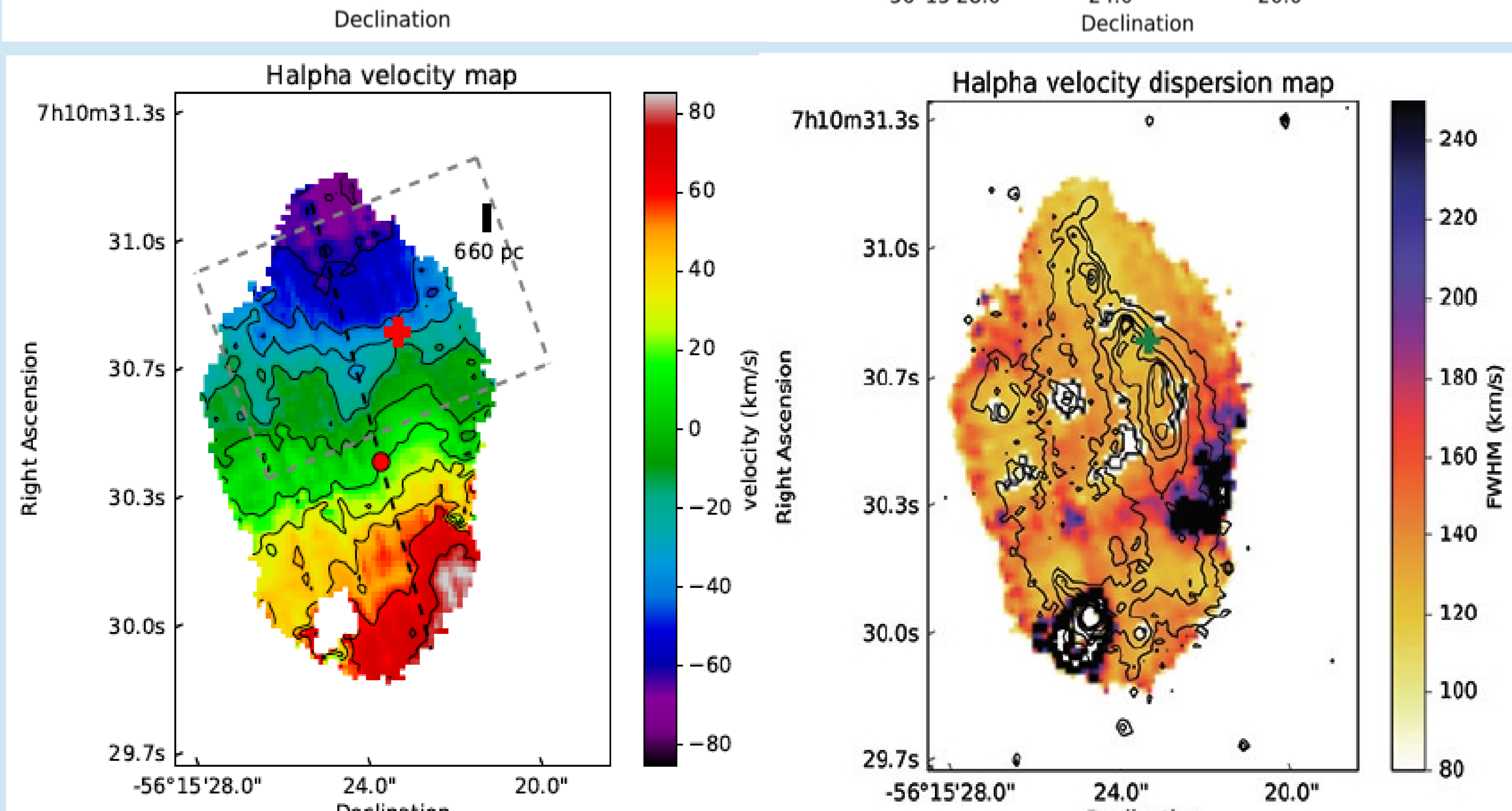


(Left panel) HST/WFC3 image of the host of GRB 100316D obtained in the filter F625W. The red cross corresponds to the astrometric location of the GRB.

(Right panel) The location and extension of the eight HII regions found by an automatic search algorithm in MUSE data. The GRB is located in between the two most bright HII regions.







(Upper panels) The metallicity maps obtained from MUSE data and considering the O3N2 and the N2 indices (Marino et al. 2013) and the N2S2 (Dopita et al. 2016) estimators

(Left panels) The ionization (log U, Diaz et al. 2000) and the star-formation rate maps, as obtained from the Hα fluxes and the Kennicutt (1989) formulation. The GRB location falls in the galaxy regions with the highest SFR and the lowest values for the metallicity.

(Lowe left panels) The velocity distribution and its dispersion 2D maps as computed from gaussian fitting of the Hα line.

(Right panel) The BPT diagram computed for each HII region as well as the shocked one. Additional GRB hosts data are also reported and compared

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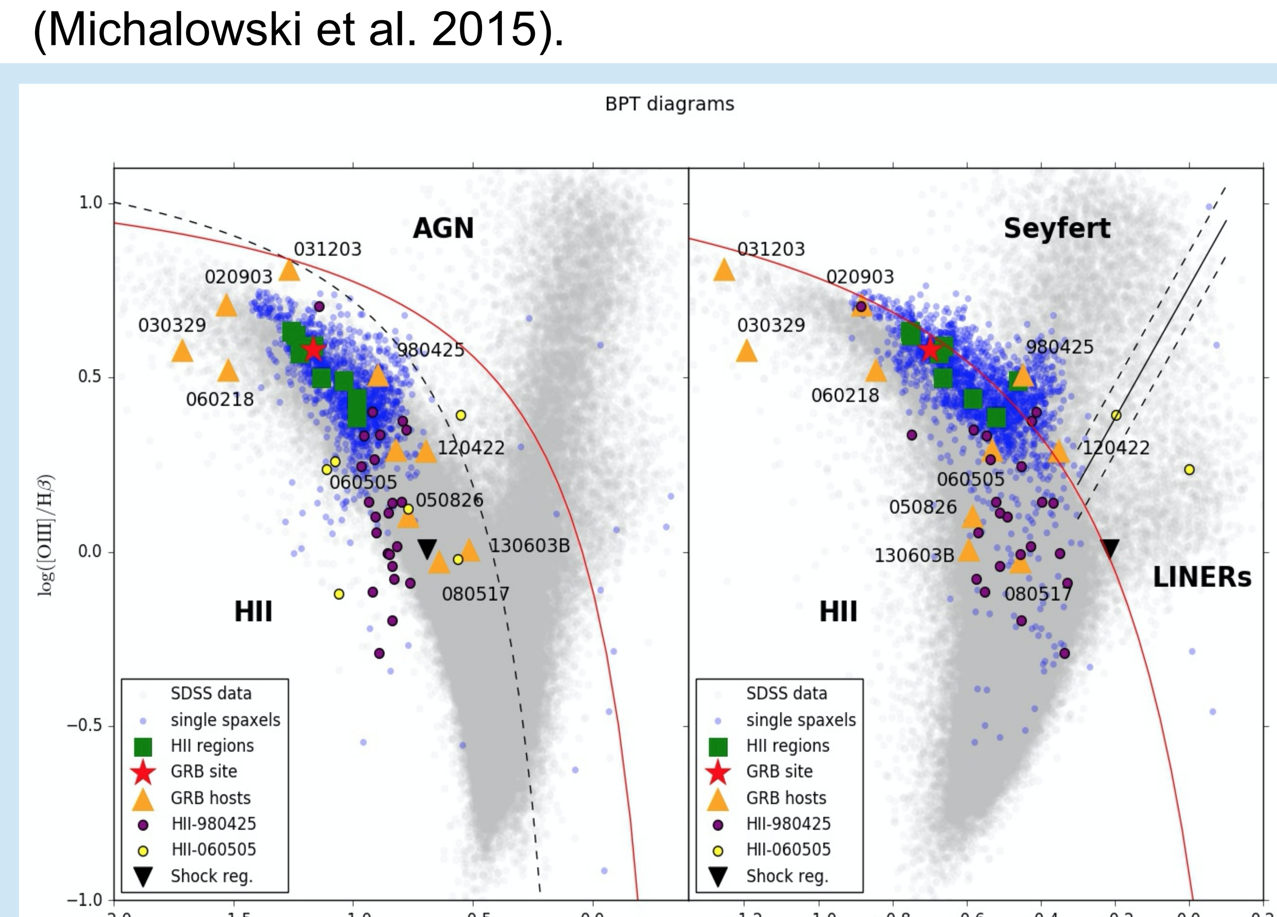
Spatial-resolved properties

The resolution and the large field-of-view of MUSE allow us to create 2D maps of gas metallicity, ionization level and star-formation rate distribution maps in the galaxy. .

The GRB exploded in the region with the lowest-metallicity, the highest star-formation rate and ionization level and the youngest age for the underlying stellar population (20-30 Myr). All these estimates match with the general results obtained for other host galaxies (with exception for the ionization level) and in particular for the other GRB host studied with MUSE (Kruhler et al. 2017).

We also report an offset of ~ 660 pc from the GRB location and the centre of the HII-1 region, the most bright region in the galaxy. This evidence suggests a possible runaway star for the progenitor of GRB 100316D, which likely received a “kick” during the early phases of the formation of the stellar cluster at the centre of the HII region.

From the velocity maps obtained through Hα gaussian fitting , we note that the FWHM map shows the presence of a central region characterized by large velocity dispersions (see the Hα maps below). A detailed analysis of this central region shows a LINER-like spectrum (see also the BPT diagrams) with enhanced metallicities. We suggest that the galaxy underwent a recent gravitational encounter with a small companion, and we are actually seeing the consequences of this merging. Additional evidences are shown in radio frequencies, where evidences for the existence of a HI compact companion located in the neighborhood of this shocked region have been reported (Michalowski et al. 2015).



***Conclusions** – The use of integral-field unit to study GRB hosts has revealed as fundamental in obtaining detailed information on the immediate GRB environment as well as onto the nature of the host galaxy. The host is a late-type dwarf galaxy characterized by the presence of multiple star-forming regions and an extended central region with signatures of on-going shock interactions. The GRB site is located at the border of the most bright star-forming region of the galaxy, characterized by the lowest metallicity, the highest star-formation rate and the youngest (~ 20-30 Myr) stellar population in the galaxy, which suggest a GRB progenitor stellar population with mass up to 20-40 MΘ. We suggest that the observed star-formation observed may have triggered by a relatively recent gravitational encounter between the host and a small faint companion.*

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