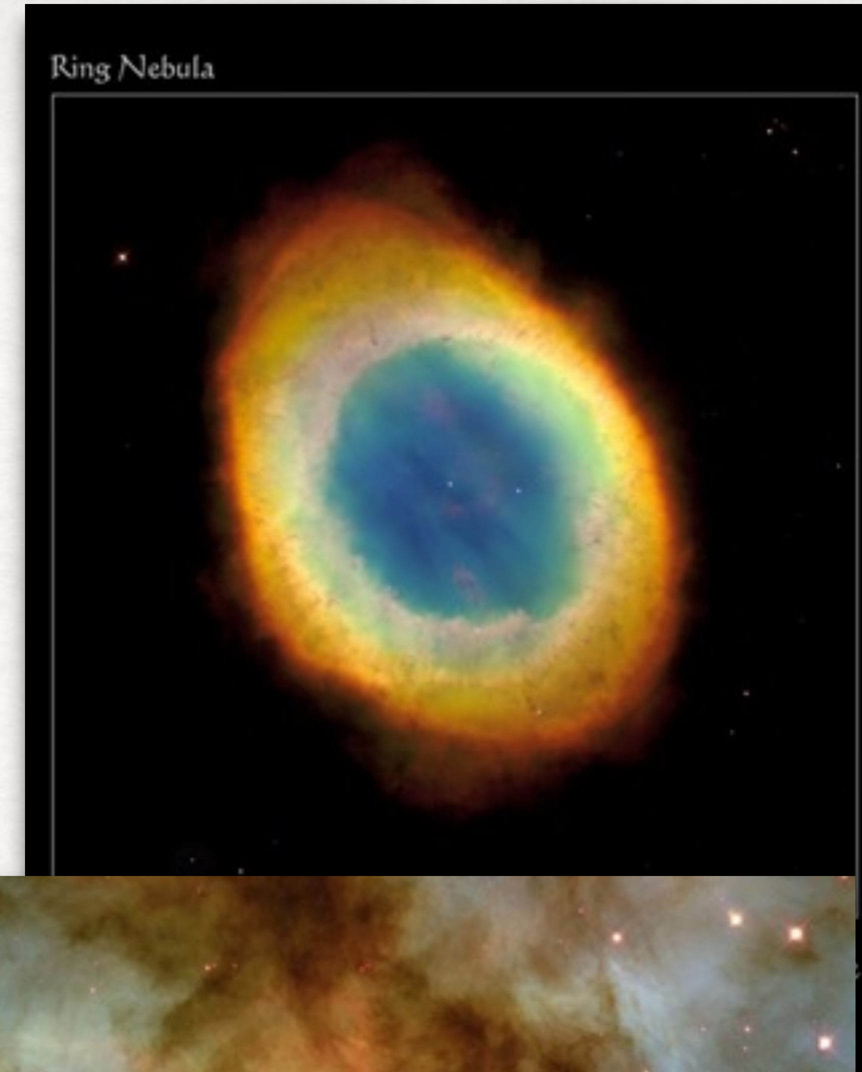
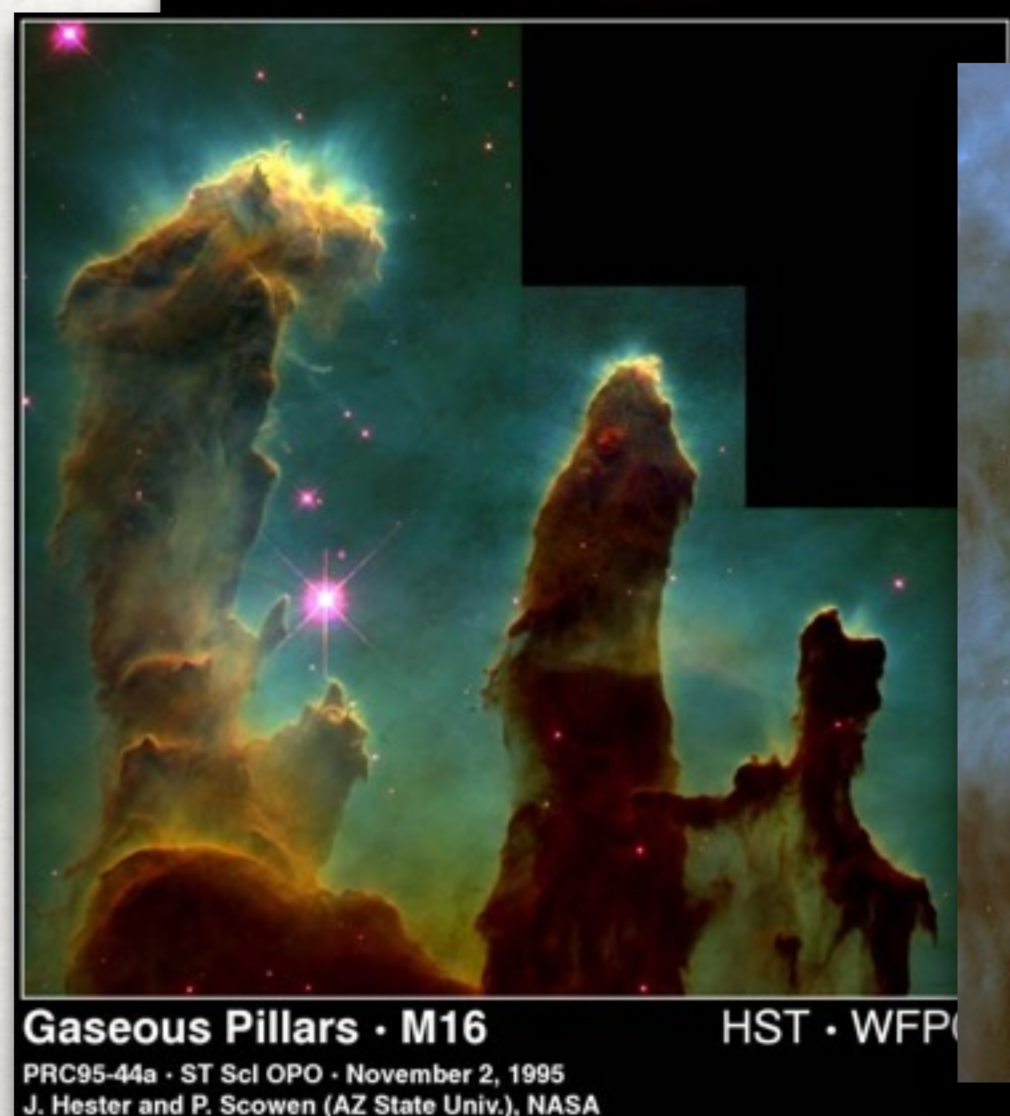
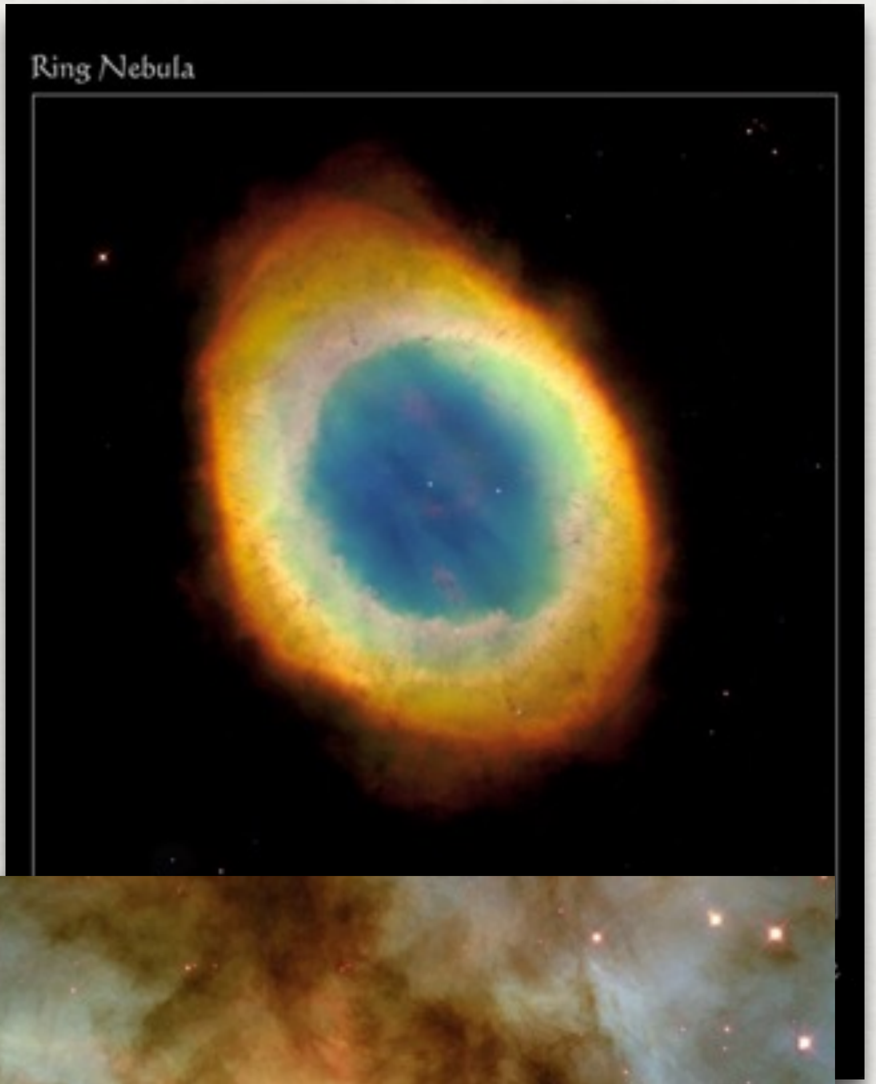
CHRISTOPHE MORISSET
IA-UNAM MEXICO

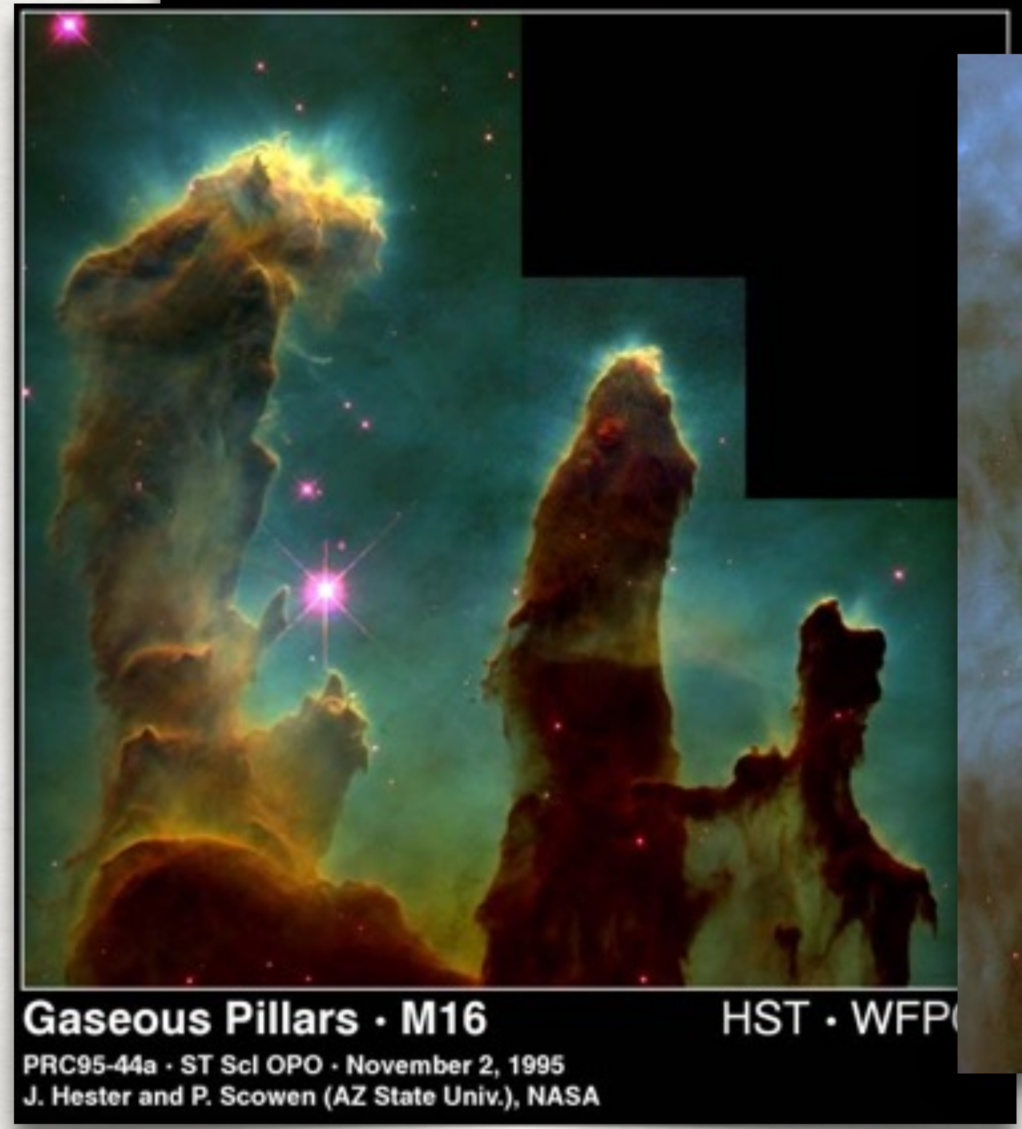
WHAT NOT TO DO WITH IFS AND MODELS


Ring Nebula

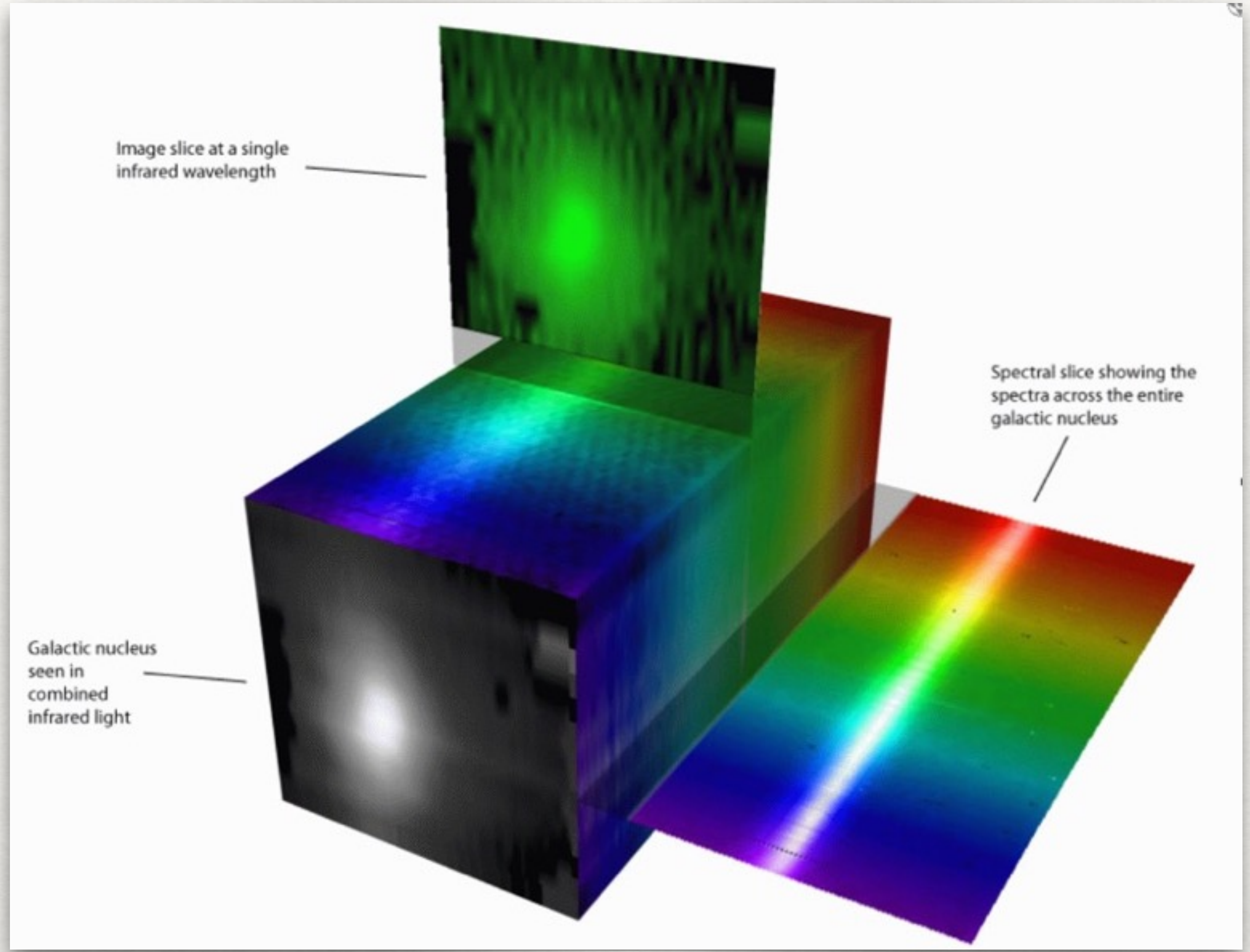

Gaseous Pillars · M16
HST · WFP
PRC95-44a · ST ScI OPO · November 2, 1995
J. Hester and P. Scowen (AZ State Univ.), NASA

colors,
colours,
couleurs,
colores





IFU,IFS, 3D SPECTROSCOPY



WONDERFUL WORLD OF IFU/IFS

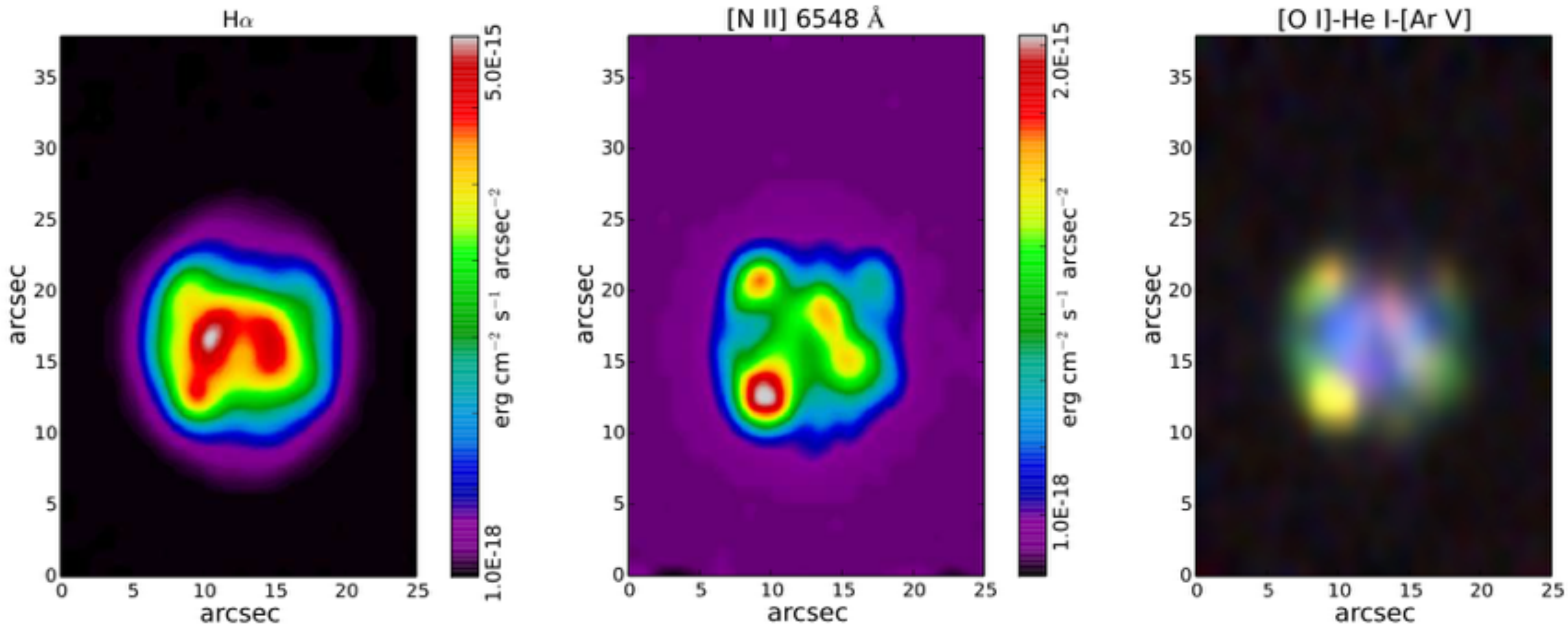


Figure 5. As Fig. 2, but for PB 6. The left and middle panels show the maps of the nebula in Hα and [N II] lines, respectively. The right panel shows **an [O I] - He I - [Ar V]** RGB color image of the object. A roughly circular PN morphology with faint extended halo (appears in [N II] maps) and three non symmetric knots appear inside the nebula. Two bright knots are pronounced in yellow (R+G) color and the third knot appears in magenta (R+B) color with a tail of magenta and green colors

IFU spectroscopy of Southern Planetary Nebulae V: Low-ionization structures

2018

A. Ali,[1,2] and M.A. Dopita,[3*]

NGC628 with SITELLE : I. Imaging Spectroscopy of 4285 HII region candidates.

L. Rousseau-Nepton[1,2,3*], C. Robert[1,2,3], R. P. Martin[3], L. Drissen[1,2,3], and T. Martin[2]

2017

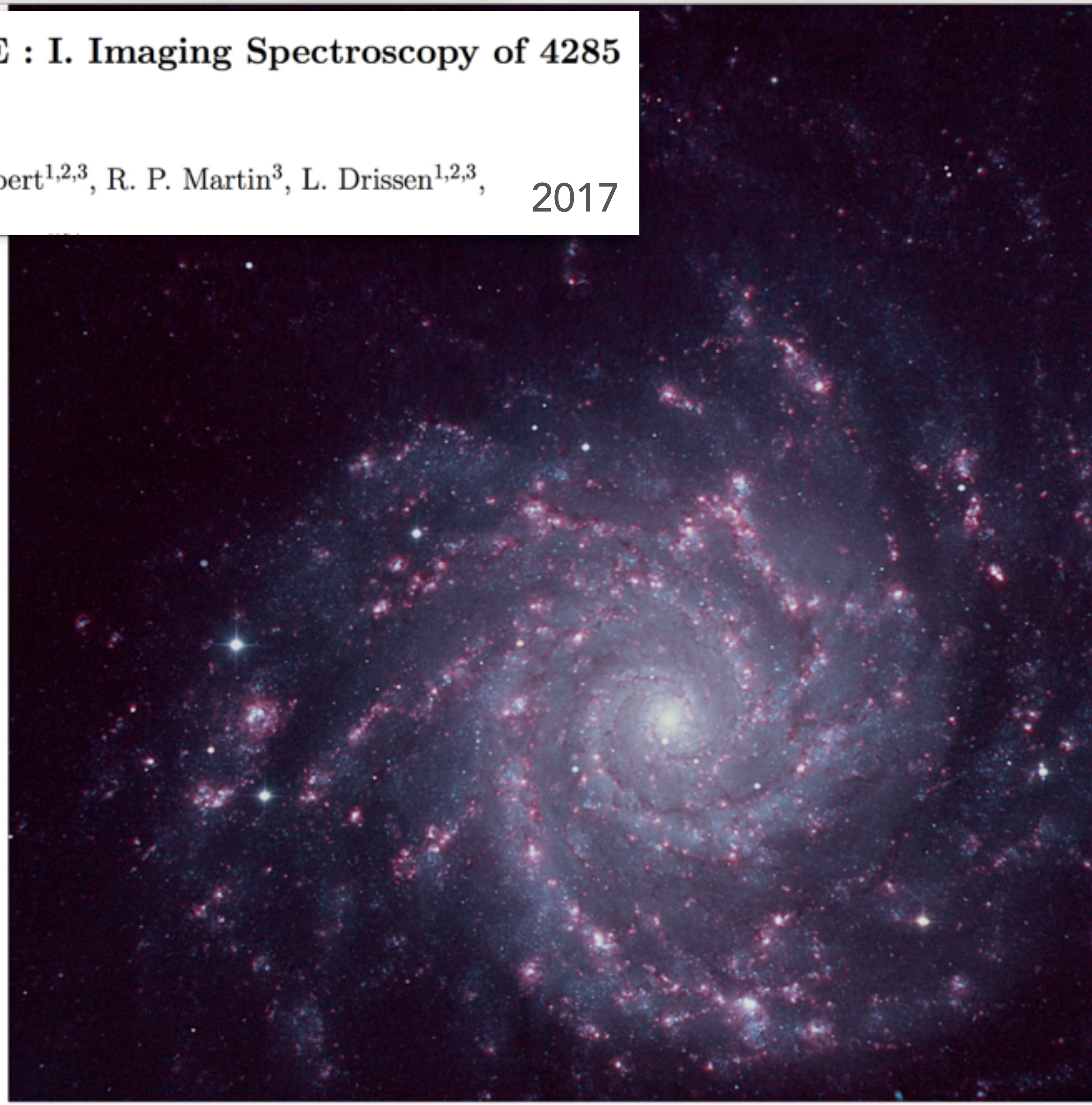


Figure 2. SITELLE's deep image of NGC 628. For each pixel, the information from the three filters was summed together along with the Hα intensity map. Adding the Hα map highlights the ionised gas emission regions (in red on the image). North is up and East is left. The FOV is 11′×11′ centred on RA 01h36m46.2s and DEC +15°48′42.8″.

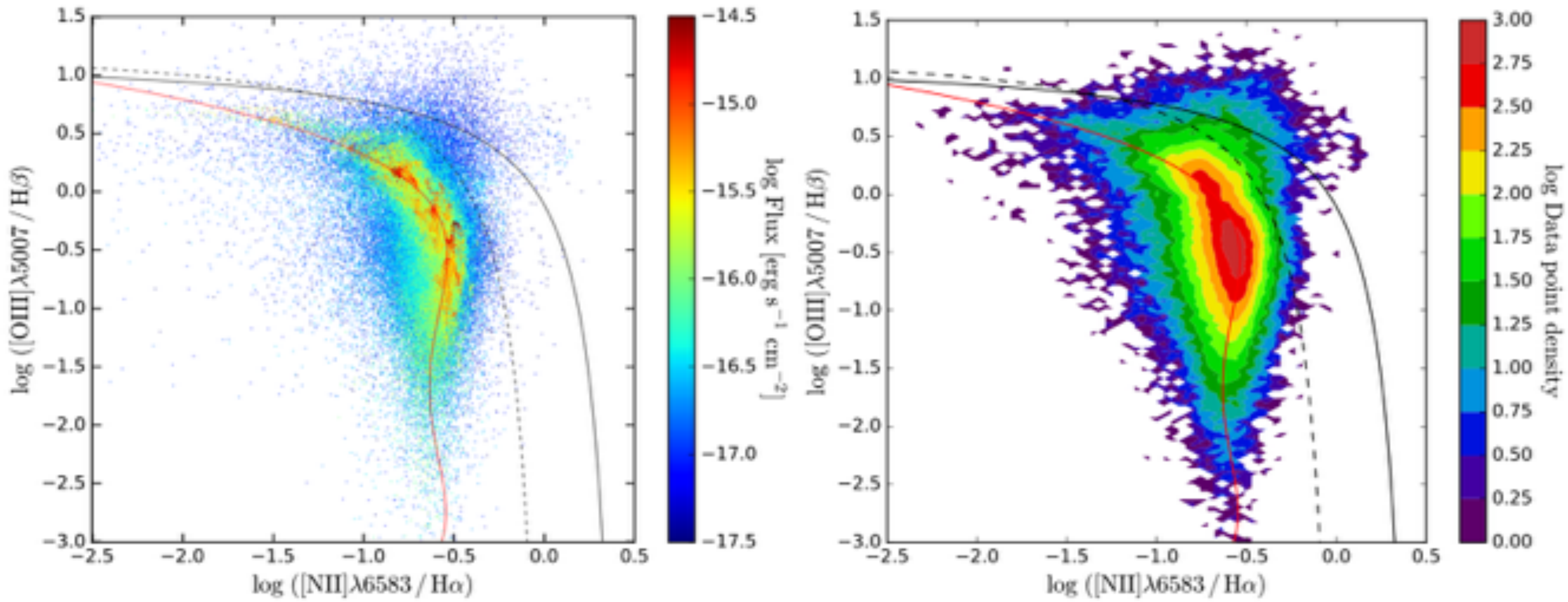


Figure 22. BPT diagram of [OIII]/Hβ vs [NII]/Hα for all the spaxels measured, on the left, colour coded according to the Hα flux, and on the right, colour coded according to the spaxel density. The dashed curve defines the BPT limit between the HII regions and the transition zone, whereas the black curve defines the BPT limit between the transition zone and the AGN regime. The red curve corresponds to the polynomial fit of the data. In the left panel, spaxel values are stacked over each other from the faintest Hα flux region to the brightest one, and therefore, bright spaxels always appear in front.

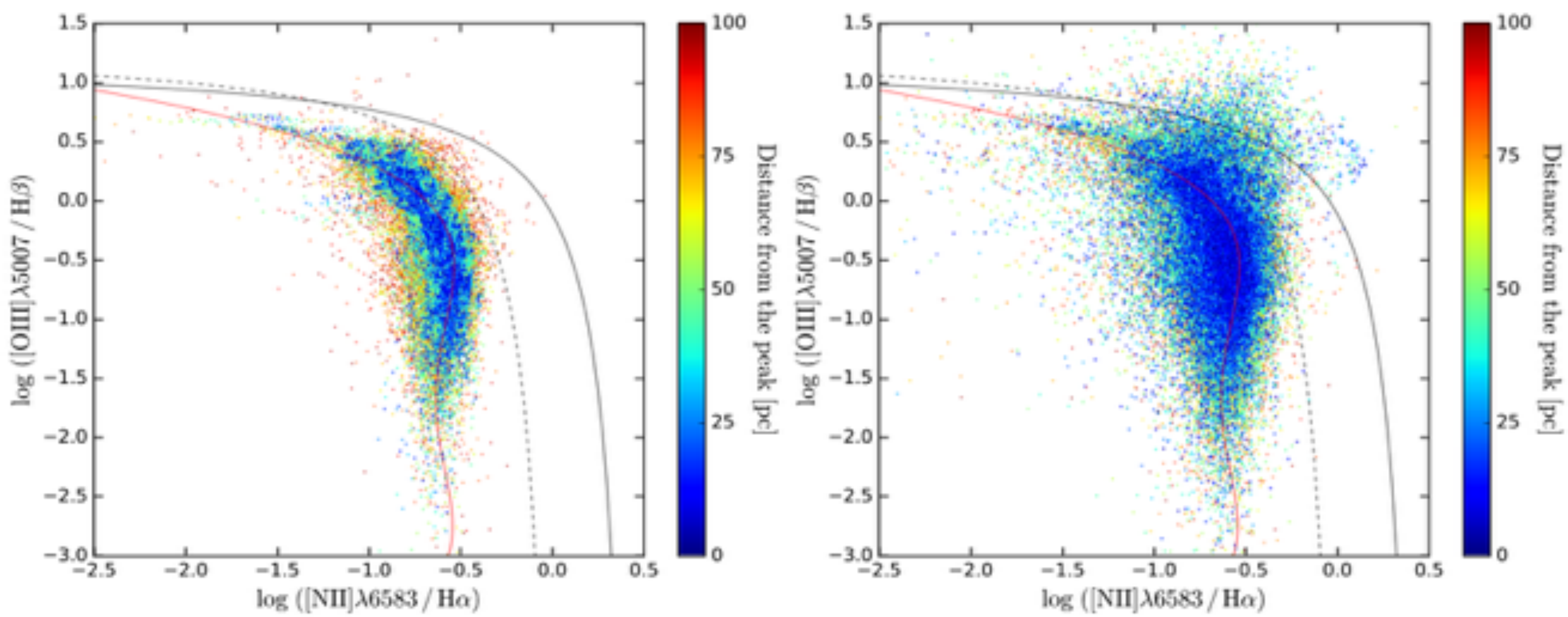


Figure 23. BPT diagram of [OIII]/Hβ vs [NII]/Hα for spaxels included in very bright emission regions (i.e. regions with an integrated Hα flux above 5×10^{-15}erg s^{-1}cm^{-2}; on the left) and, for moderately bright spaxels (i.e. spaxels with an Hα flux above 5×10^{-16}erg s^{-1}cm^{-2}; on the right). The plots are colour coded according to the spaxel distance to its emission peak. Spaxel values are stacked over each other from the more distant to the closest one, and therefore, closest regions always appear in front. The curves are as in Figure 22.

Rousseau-Nepton+17

BACK TO THE ROOTS

ONION STRUCTURE OF PHOTOIONIZED NEBULAE

- For a given object, the ionizing source parameters are fixed.
- Ionization parameter: $U = Q_0 / 4.\pi.\mathbf{r}^2.N_e.c$
- U is changing with the position **r** in the nebula.
- Full models are integrated over the volume (**r**).
- If something is changing from place to place in a given object, it is hopefully related to the position (**r**).

WOLF RAYET BUBBLE

- From upper to lower part of the BPT diagram: U.
- The only way to move points from right to left: changing N/O.

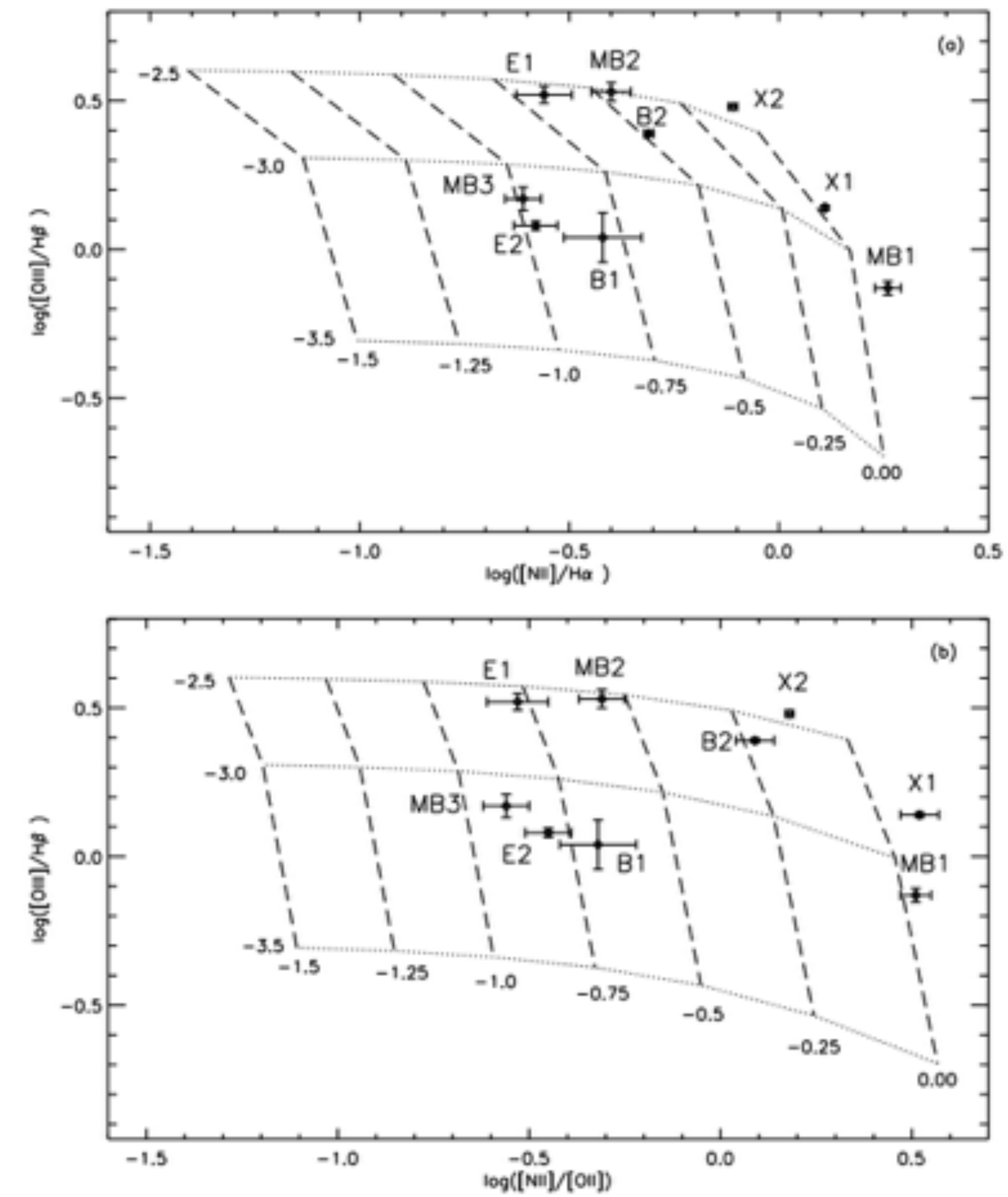


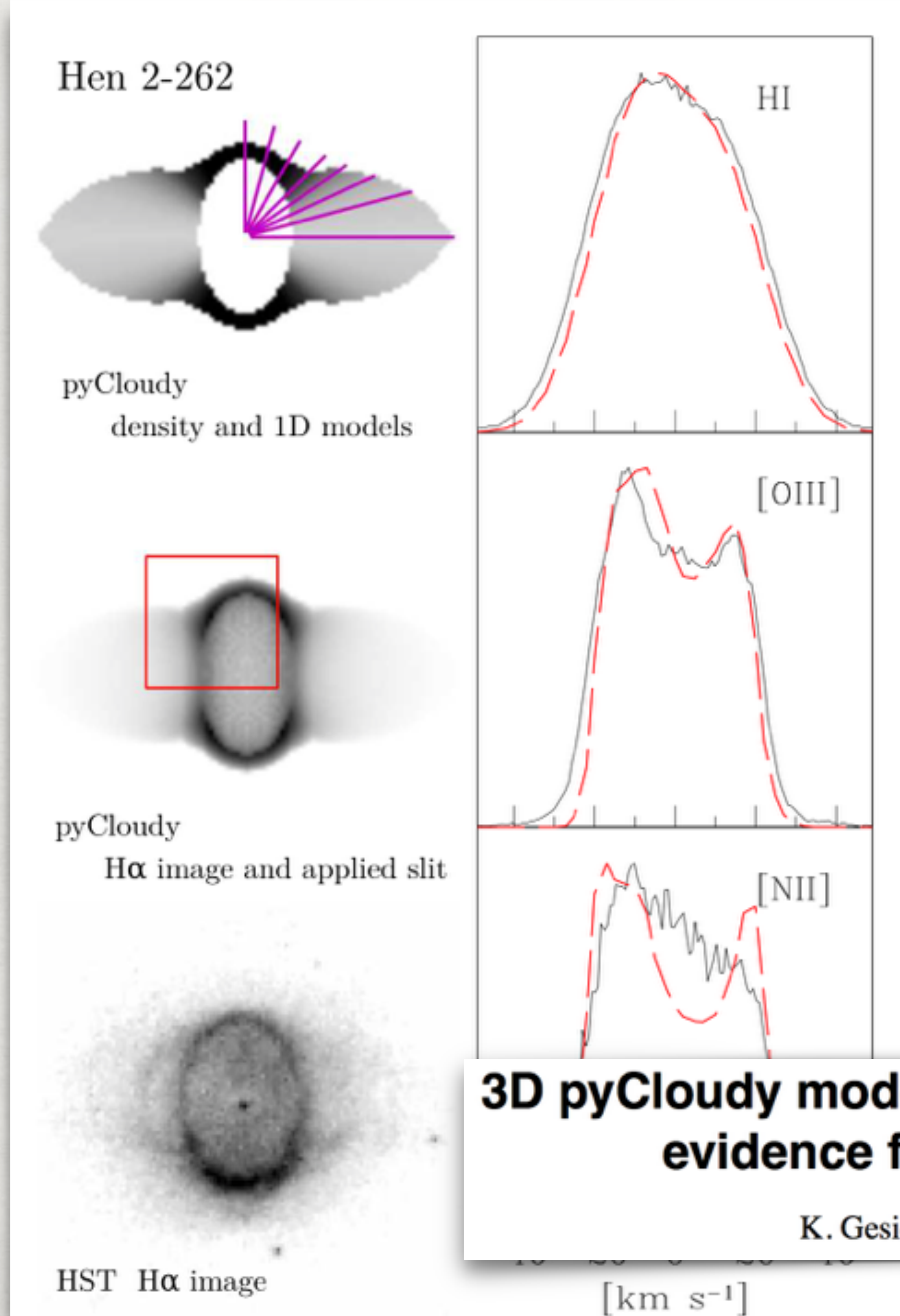
Fig. 11. Diagnostic diagrams containing the results of our photoionization models and observed data. **a)** [OIII]$\lambda\lambda$5007/ Hβ vs. [NII]$\lambda\lambda$6584/Hα and **b)** [OIII]$\lambda\lambda$5007/Hβ vs. [NII]λ6584/[OII]$\lambda\lambda$3726, 3729. In all the diagrams, the dotted lines connect points with the same ionization parameter. The dashed lines connect curves of equal log (N/O). The respective values are indicated at the beginning of curves. For all the models we assumed 12 + log (O/H)) = 8.47. Points are values of integrated spectra placed according to their intensities ratios (named as in Table 3 and Fig. 9).

Fernández-Martín+12

3D MODELING

- Pioneer works by Kirkpatrick in… 1970
- Ahangaba (1996, Sao Paulo Viegas, Gruenwald + Aleman)
- MOCASSIN (UCL Ercolano et al.)
- CMacIonize (2018, B. Vandenbroucke, K. Wood)
- Pseudo-3D (based on NEBU or Cloudy, IDL or Python, Morisset)

PSEUDO-3D



3D pyCloudy modelling of bipolar planetary nebulae: evidence for fast fading of the lobes★

K. Gesicki[1], A. A. Zijlstra[2], and C. Morisset[3]

2016

A Consistent Spectral Model of WR 136 and its Associated Bubble NGC 6888

J. Reyes-Pérez[1*], C. Morisset[1], M. Peña[1] and A. Mesa-Delgado[2].
[1] *Instituto de Astronomía, Universidad Nacional Autónoma de México*
[2] *Instituto de Astrofísica, Facultad de Física, Pontificia Universidad Católica de Chile*
2015

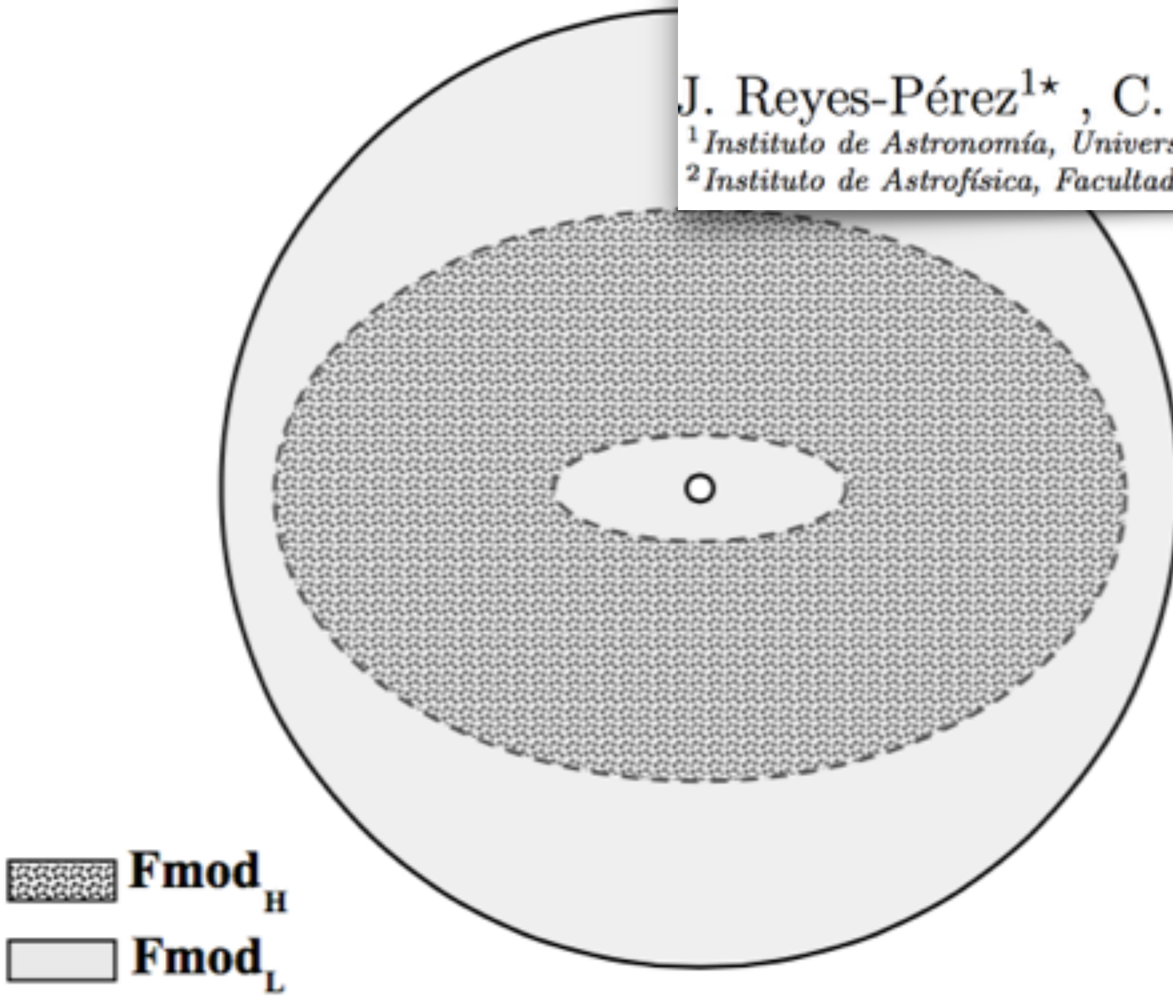


Figure 5. Scheme of the geometry assumed to build the photoinization model of NGC 6888. We can see the high-density and clumpy component ($Fmod_H$) as an ellipsoide covered by the spherical low-density component ($Fmod_L$). In the model, the edges of the ellipsoide match the size of the observed semi-axis of NGC 6888.

- 2 components 3D model.
- 2 densities:
  - Low density for O^{++}
  - High density for X^{+}

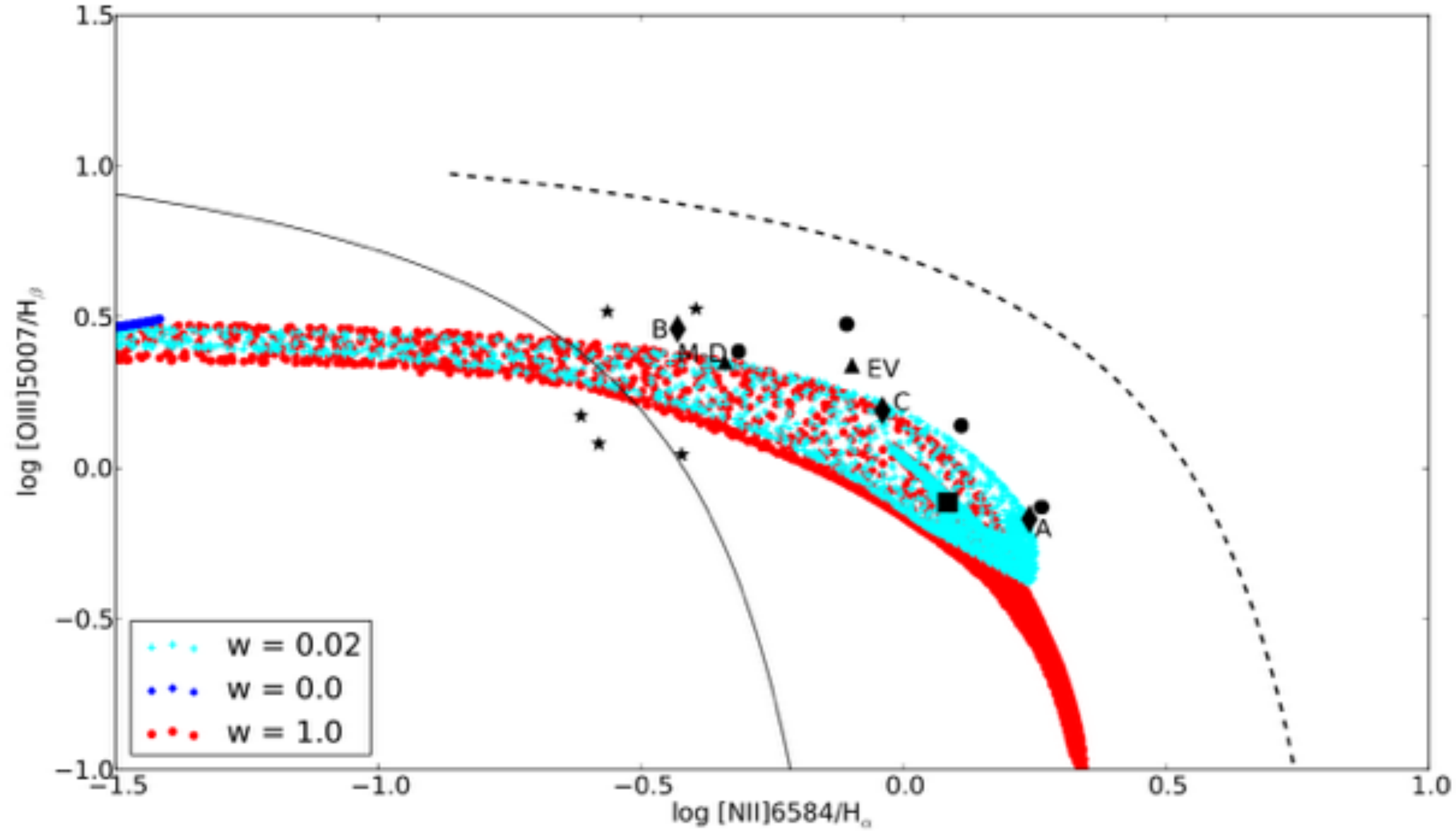


Figure 7. Plasma diagnostic diagram [O III]/Hβ vs. [N II]/Hα. The solid curve corresponds to the diagram in Kauffmann et al. (2003) and the dashed curve is the same one but shifted by 0.96 dex given the difference between the N/O values in that work and in ours. For three different w values, all the points that make the photoionization model of NGC 6888, using *star3* as ionization source, are shown. The observed ratios are marked as black diamonds and the black square represents the values of integrated fluxes coming from the whole nebula. The observations by FM12 are also shown: stars represent the N-poor regions in the immediate outer zone of NGC 6888 while the black points are observations of the main structure of the nebula with N-rich abundance. Observations by EV92 and M-D14 are also show in the diagram as black triangles.

Reyes-Perez+15

We reproduce the whole scatter only by position effects, no N/O gradient at all!

HII REGIONS

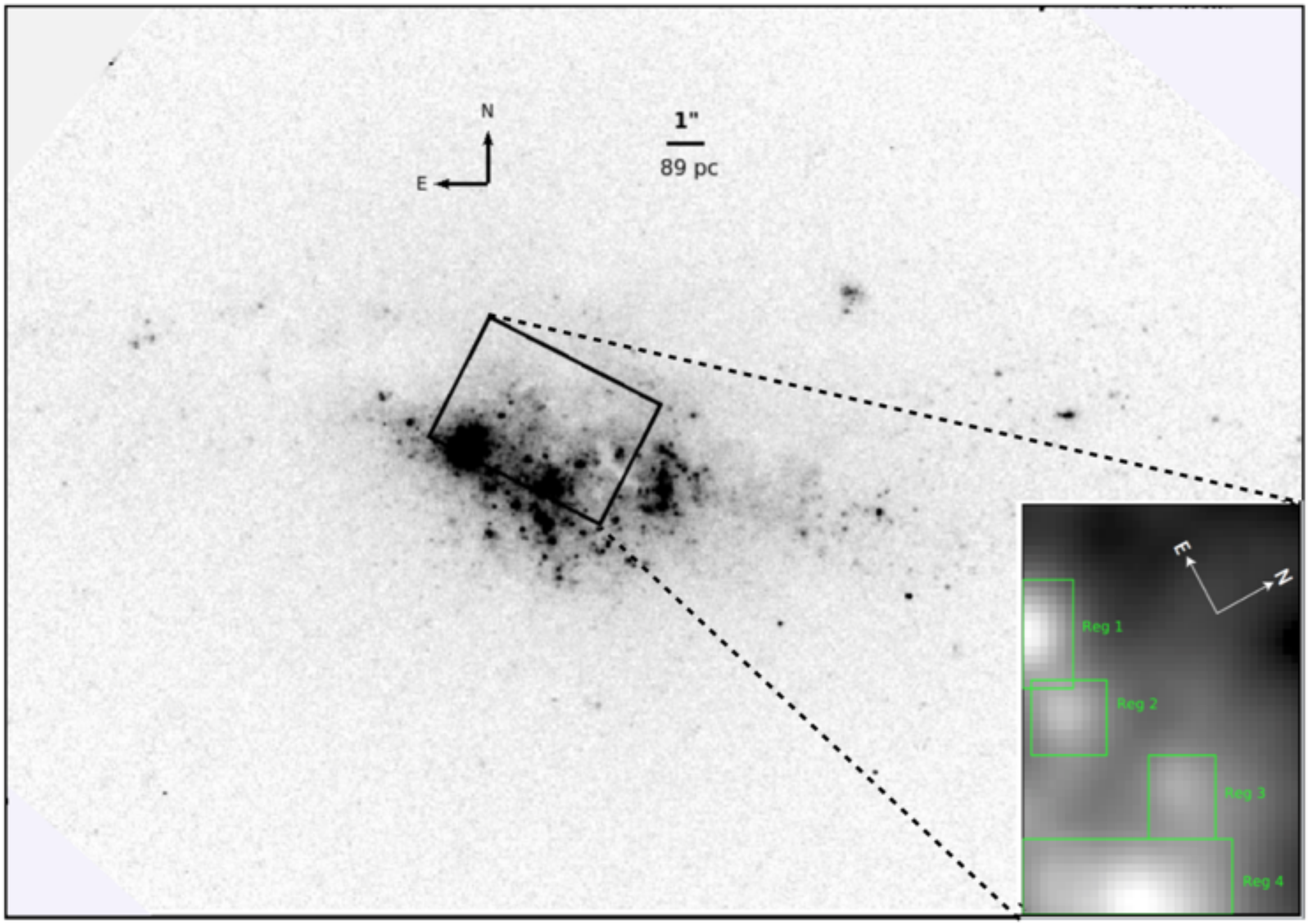


Figure 2. Left panel: HST image of NGC 4670 taken in the filter F439W. The black rectangular box in the centre represents the GMOS aperture (3.5″ × 5″). The HST image has a spatial scale of 0.05″ pixel^{-1}. North and East on the image is shown by the compass on the top-left of the figure. Right panel: Hα map of the FOV obtained from the GMOS-IFU shows the four H II regions (Reg 1, Reg 2, Reg 3, Reg 4) in green rectangular boxes. The compass on this panel shows North and East on our FOV.

Kumari+18

SPAXEL DISTRIBUTIONS

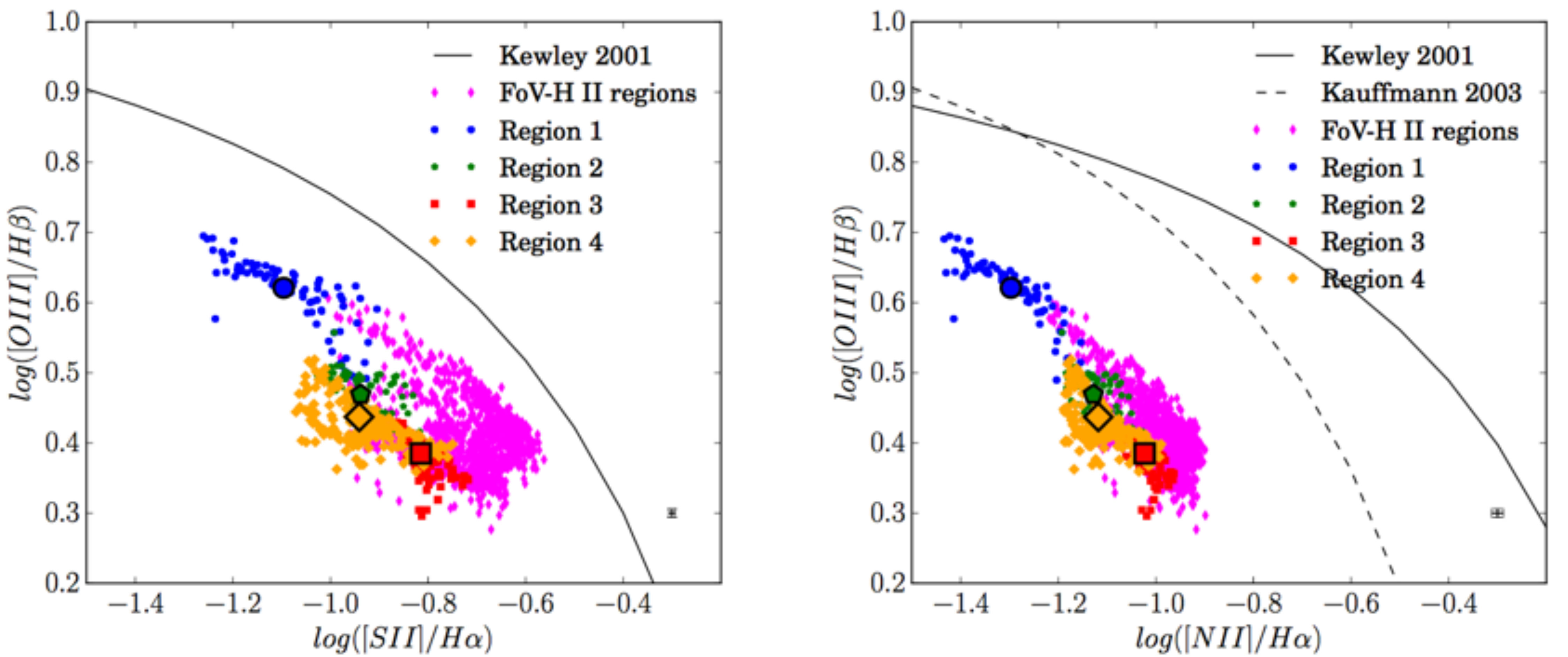


Figure 8. Emission line ratio diagnostic diagrams: [O III]/Hβ versus [S II]/Hα (left), and [O III]/Hβ versus [N II]/Hα (right). Black solid curve and dashed curve represent the theoretical maximum starburst line from Kewley et al. (2001) and Kauffmann et al. (2003) respectively, showing a classification based on excitation mechanisms. The line ratios of the four H II regions are colour-coded as follows: region 1: blue circle, region 2: green pentagon, region 3: red square, region 4: orange diamond. Smaller markers denote the spatially-resolved (spaxel-by-spaxel) line-ratios and the bigger markers denote the line-ratios obtained from the integrated spectrum of the corresponding regions. Magenta coloured markers denote the spatially-resolved line-ratios of the regions of FOV excluding the four H II regions. The size of errorbars varies for line ratios and the median error bars are shown in the right corner of each panel. The error bars on the line ratios obtained from the integrated spectra of the four H II regions are smaller than the markers used here.

Kumari+18

HII-CHI_mistry code

Using a database of full models and looking for the closest model for each spaxel, one can determine some parameters.

Impressive gradients!

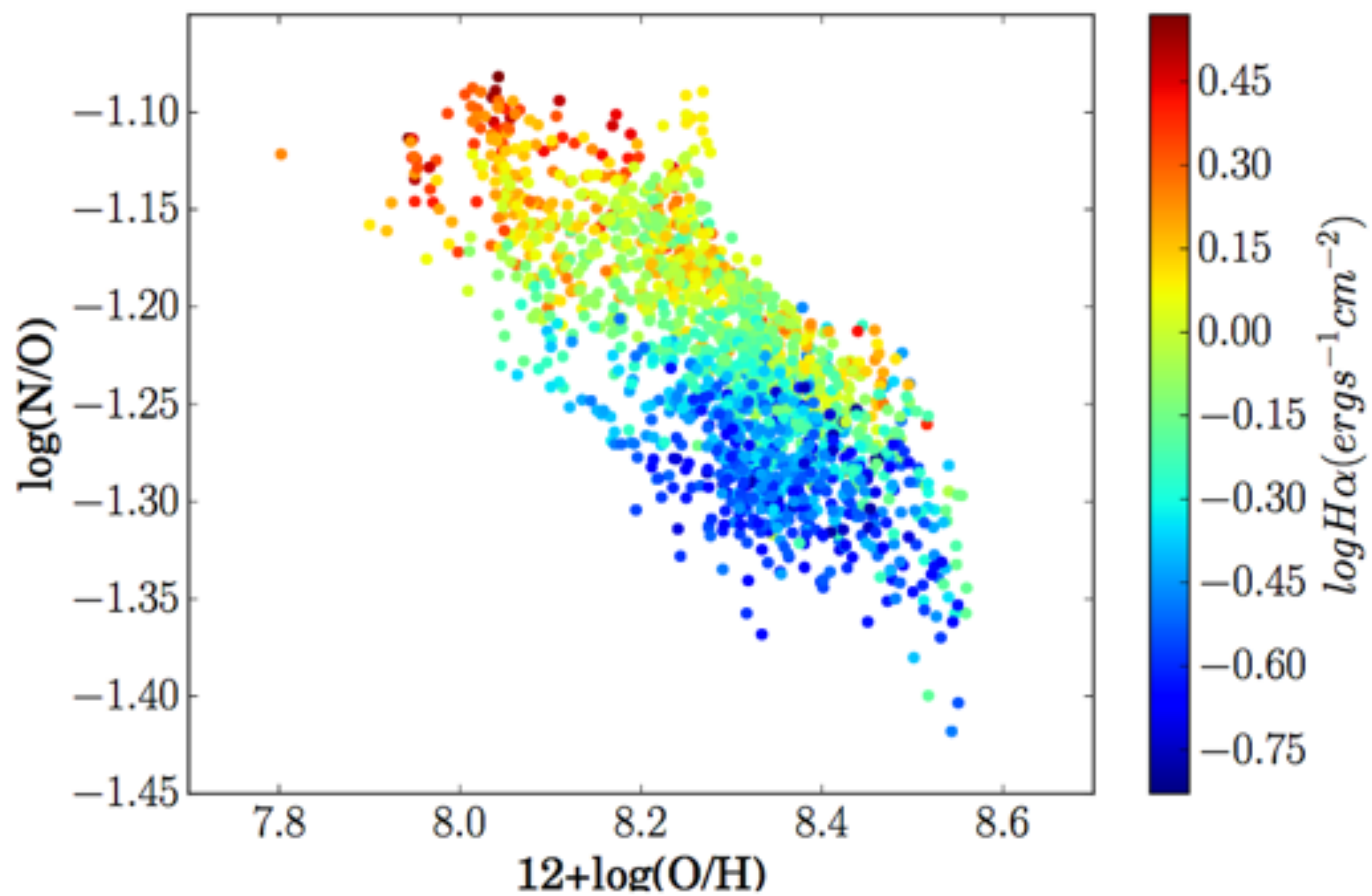
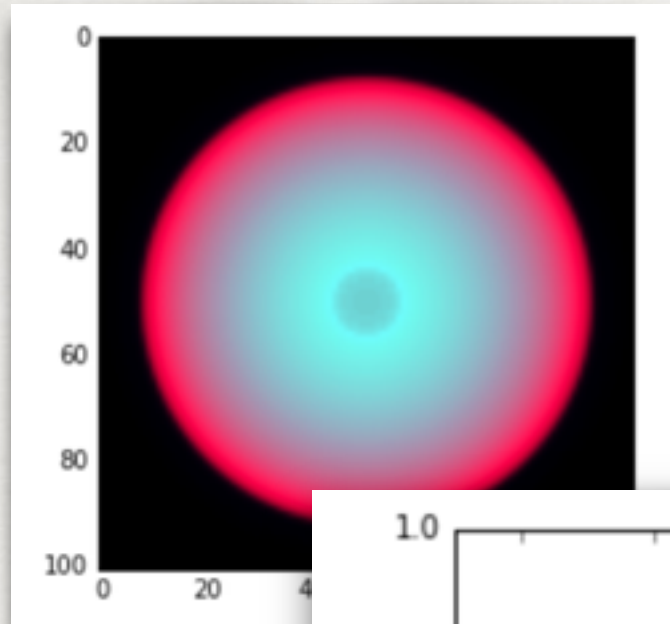
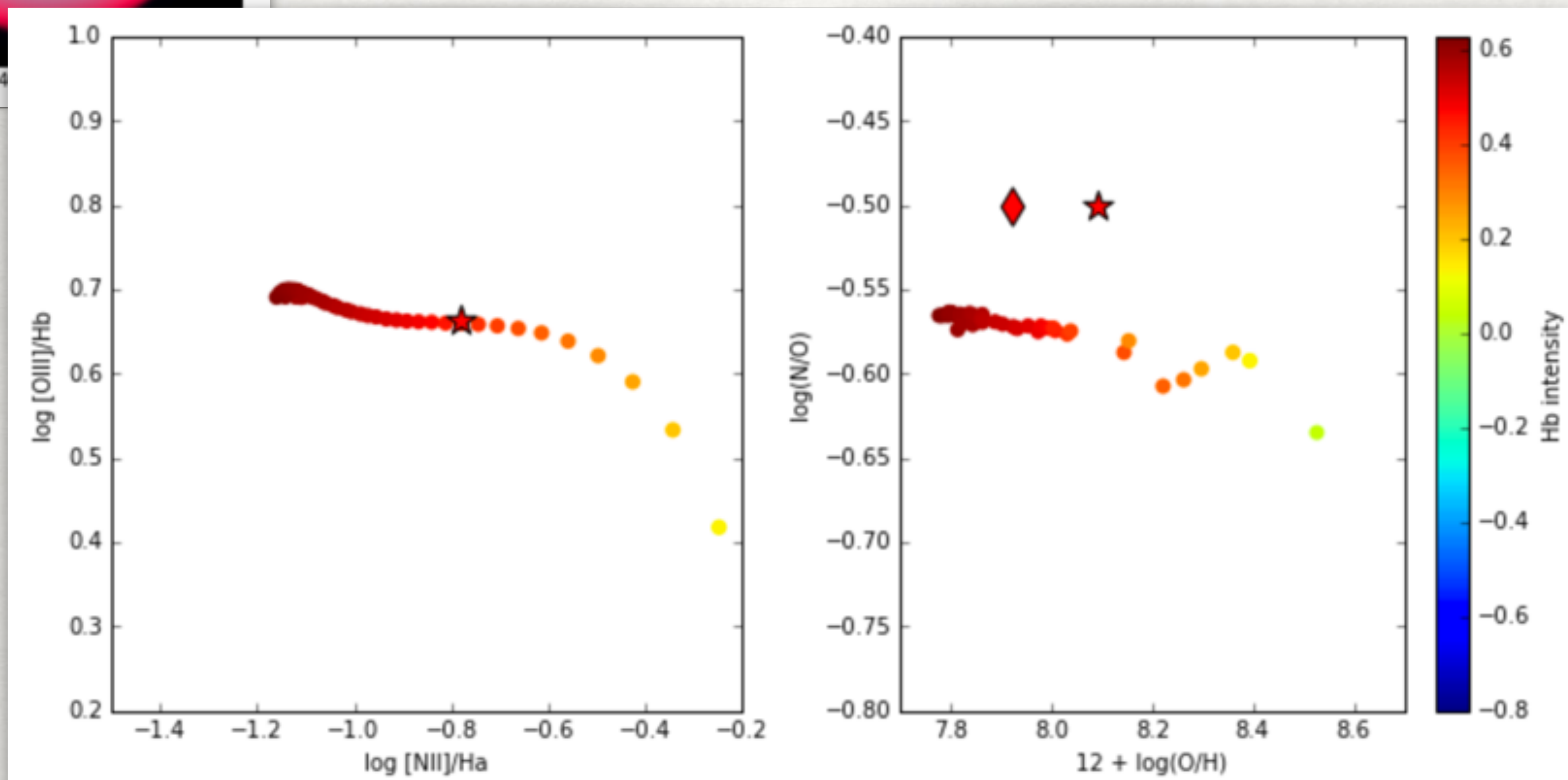


Figure 23. Spatially-resolved relationship between log(N/O) and 12 + log(O/H), where data points are obtained from HII-CHI-mistry code and are colour-coded with respect to the intrinsic Hα fluxes in the corresponding spaxels. We find that the spaxels with lower metallicity and higher log(N/O) also show higher Hα fluxes, whereas the spaxels with higher metallicity and lower log(N/O) show lower Hα fluxes. Hα being a proxy for current (< 5 Myr) star-formation, the negative trend in the log(N/O) versus metallicity is apparently dependent on the on-going star-formation.

Kumari+18

VERY SIMPLE SPHERICAL MODEL





Spaxel distribution of the model. Using the same technique and code leads to…

… apparent gradient. BUT the model is chemically homogeneous!

EVEN CLASSICAL ABUNDANCES?

- Abundances in nebulae are determined through 2 main ways:
  - **Direct method**:
    - determination of Te, Ne using diagnostics (e.g. [SII], [OIII] line ratios)
    - determination of the ionic abundances (e.g. O^{+}, O^{++})
    - determination of the total abundances (using ICFs, derived from photoionization models **of full nebulae**)
  - **Strong line methods:**
    - based on calibrations obtained either by direct method or by photoionization models of **full nebulae**.

ICF changes depending on the position in the nebula.

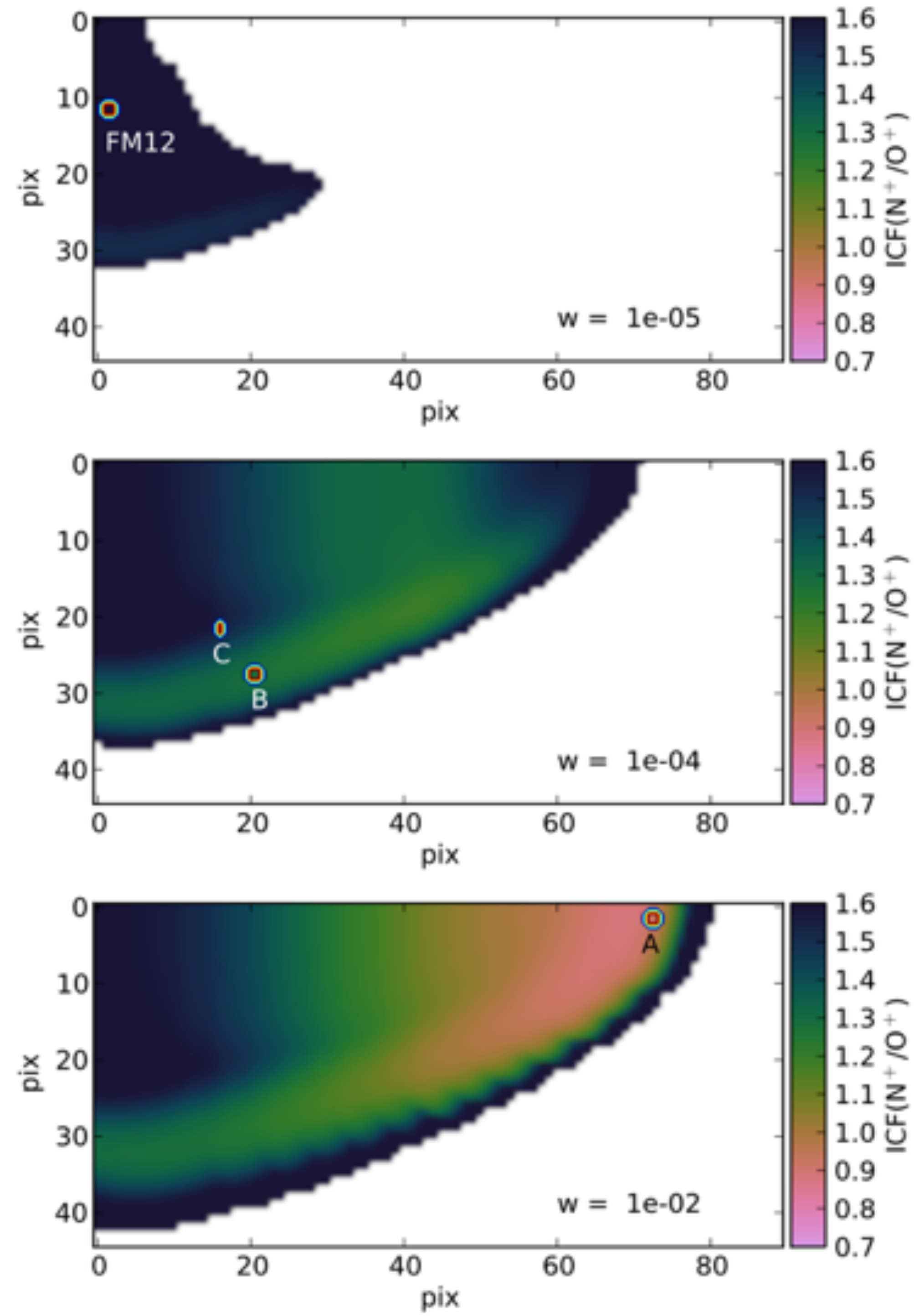


Figure 8. Map of the ICF for the N^+/O^+ ratio from a quadrant of our best photoionization model which is chemically homogeneous. The star is assumed to be at the origin of the map. Three different values of w were used to show how the values of the ICF changes over the whole structure of nebula. Our positions and the position of FM12 are shown.

Reyes-Perez+15

PLANETARY NEBULA

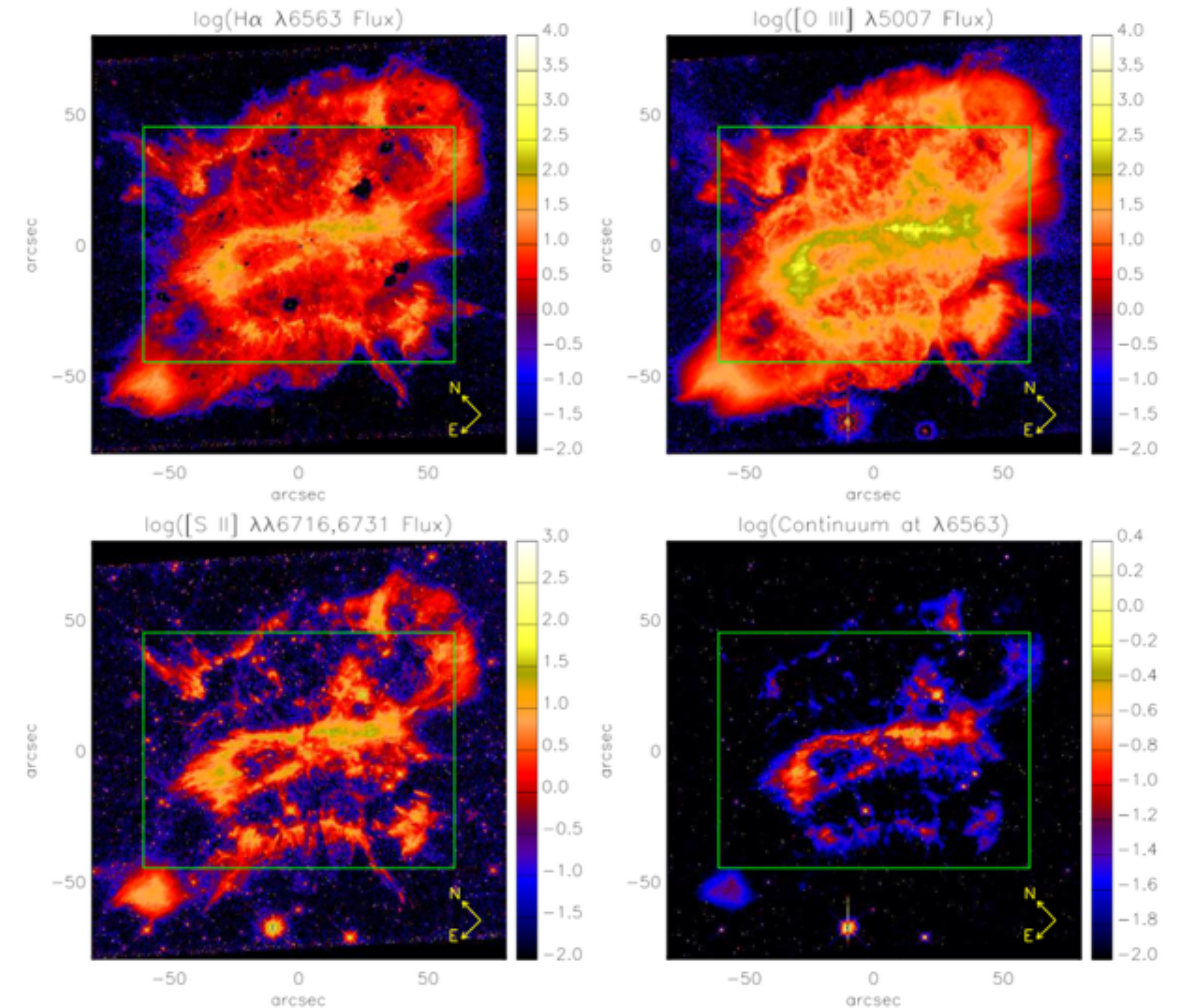
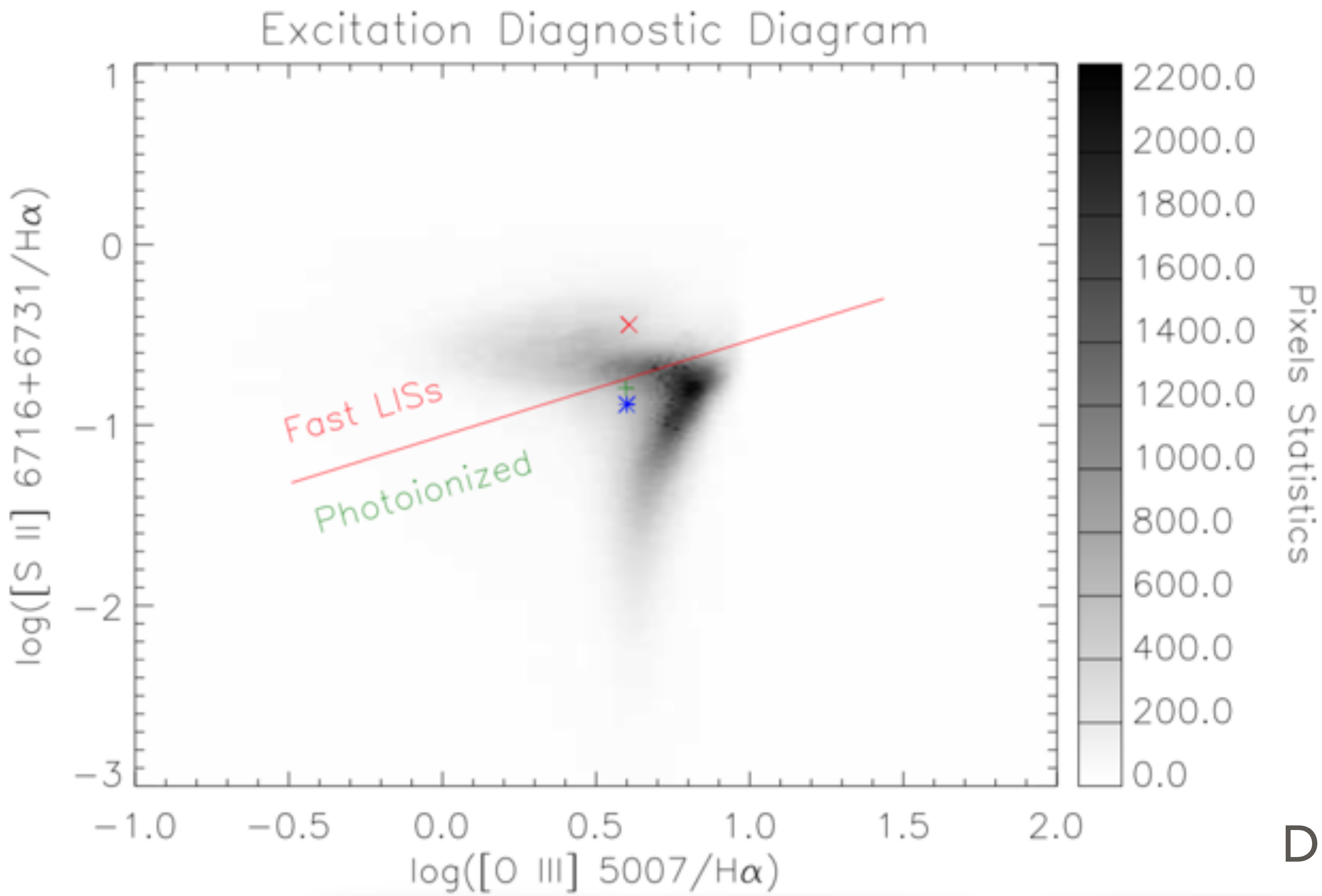


Figure 1. From left to right, and top to bottom, dereddened, continuum-subtracted flux maps on logarithmic scales (unit in 10^{-15} erg cm^{-2} s^{-1} arcsec^{-2}) of Hα λ6563, [O III] λ5007, [S II] $\lambda\lambda$6716,6731 emission lines, and continuum flux-density on a logarithmic scale (unit in 10^{-15} erg cm^{-2} s^{-1} arcsec^{-2} Å^{-1}) estimated at λ6563. Images include only pixels with at least statistically significant 1σ sky. The green rectangle indicates the $120'' \times 90''$ region of NGC 5189 used for detailed diagnostic mappings. Note that the upper value of the colorbar for the continuum map has been scaled down to show the faint nebular continuum.

Danehkar+17



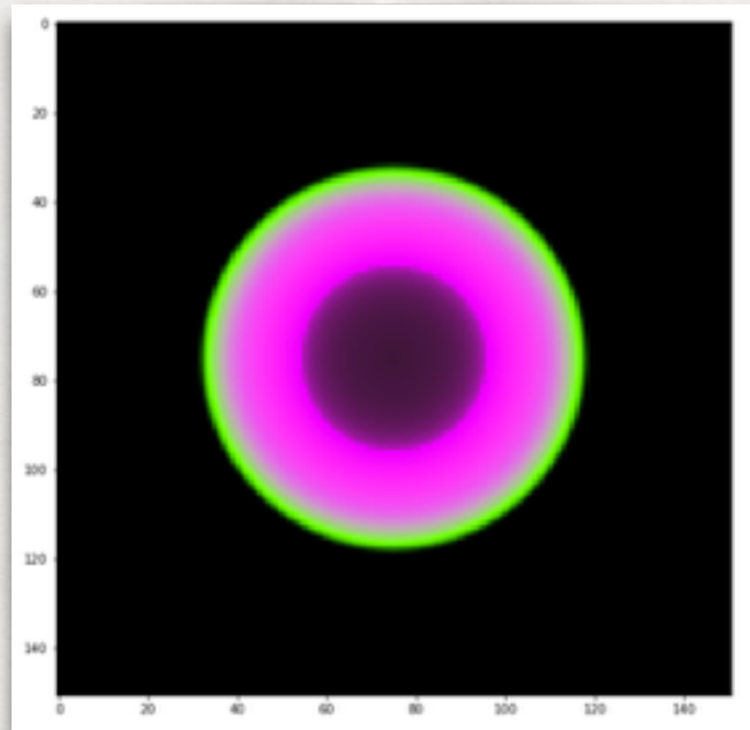
Danehkar+17

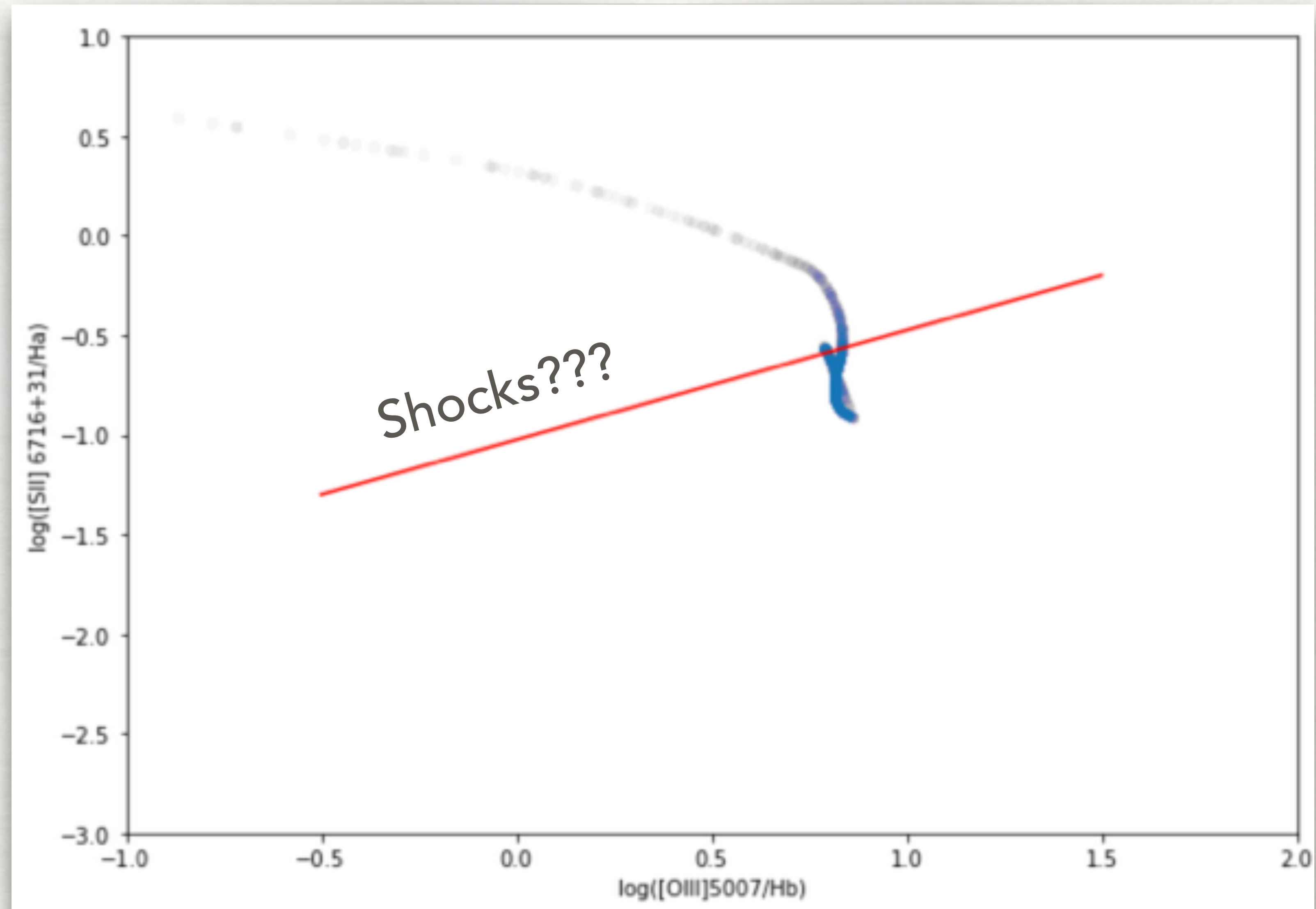
Figure 2. Excitation diagnostic diagram and BPT diagram of the inner region of NGC 5189, covering a 120″ × 90″ region (see Fig. 1). Top panel: Excitation diagnostic diagram presents logarithmic ratio maps of [O III]/Hα and [S II]/Hα. Bottom panel: BPT diagram presents logarithmic ratio maps of [O III]/Hβ and [S II]/Hα. Solid black lines show the boundaries of LINER-like and Seyfert-like activities from (Kewley et al. 2006). The solid red line depicts the nebular photon-shock dividing line in each panel chosen based on the shock models from Raga et al. (2008), as described in the text. The star points (∗) show the mean flux ratios of the 120″ × 90″ region, while the cross (×) and plus (+) points depict the flux ratios from García-Rojas et al. (2012) and Kingsburgh & Barlow (1994), respectively.

Spaxel to spaxel changes in the « BPT » diagram may be interpreted as different excitation source…

… while it may be due to radial ionization structure.

SIMPLE 3D MODEL





No shocks at all! [SII] lines are produced at the recombination front of the nebula.

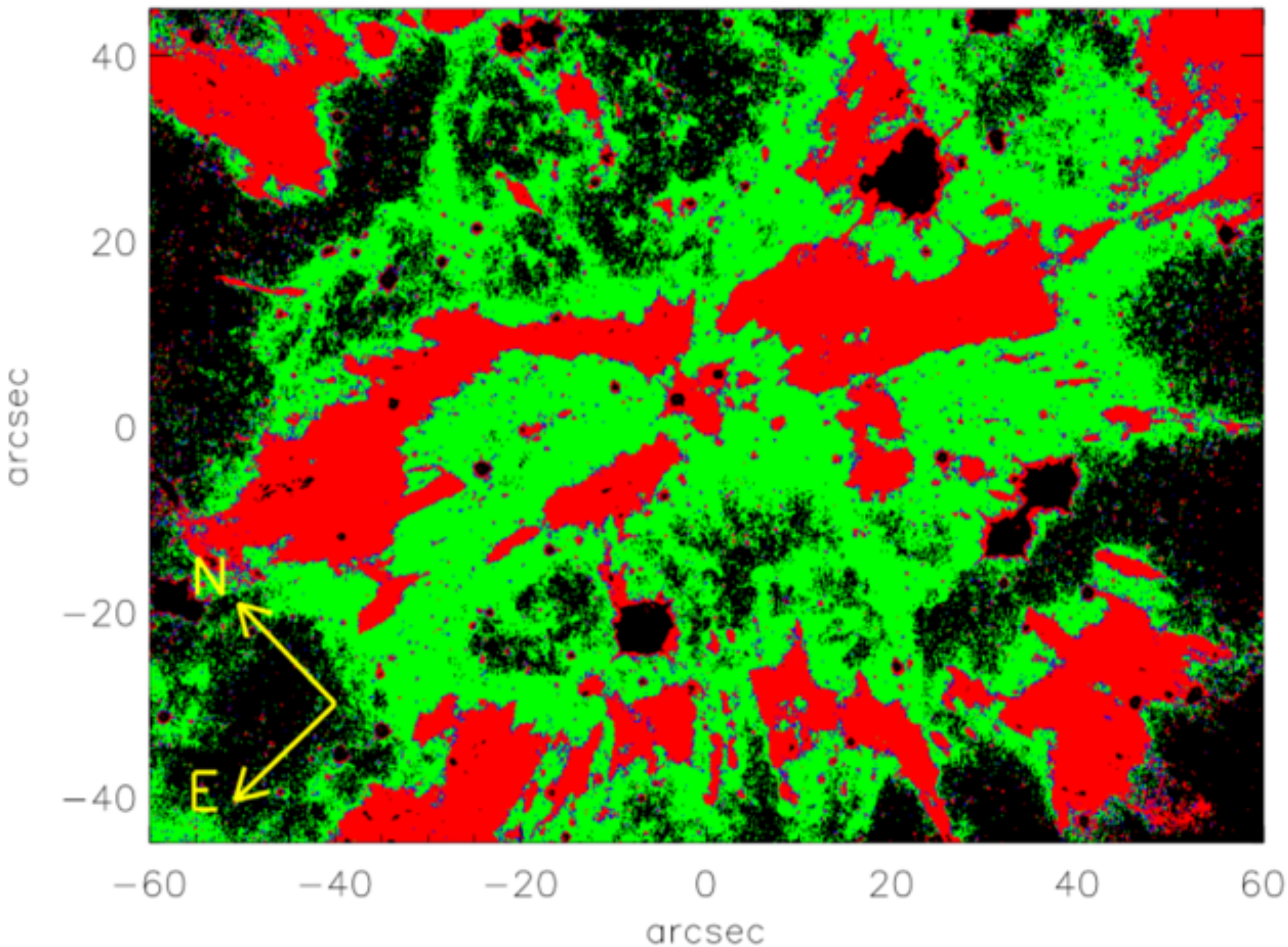


Figure 3. Spatially-resolved diagnostic map of the inner region of NGC 5189, covering a 120″ × 90″ region centered on its [WO] central star, as shown in Fig. 1. The two pixel groups are color-coded according to their locations on the excitation diagnostic diagram in Fig. 2. Red pixels correspond to fast, low-ionization regions, and green pixels correspond to photo-ionized regions. Black pixels have either only one diagnostic line ([O III] or [S II]), or one or both of diagnostic lines without at least 1σ of the mean value of the sky region.

Is there any shocks in this PN?

Or is there just a structuration of the ionization…

Danehkar+17

The Hubble Heritage Project

THE GLOWING EYE OF NGC 6751

Astronomers using NASA's Hubble Space Telescope have obtained images of the strikingly unusual planetary nebula, NGC 6751. Glowing in the constellation Aquila like a giant eye, the nebula is a cloud of gas ejected several thousand years ago from the hot star visible in its center.

"Planetary nebulae" are named after their round shapes as seen visually in small telescopes, and have nothing else to do with planets. They are shells of gas thrown off by stars of masses similar to that of our own Sun, when the stars are nearing the ends of their lives. The loss of the outer layers of the star into space exposes the hot stellar core, whose strong ultraviolet radiation then causes the ejected gas to fluoresce as the planetary nebula. Our own Sun is predicted to eject its planetary nebula some 6 billion years from now.

The Hubble observations were obtained in 1998 with the Wide Field Planetary Camera 2 (WFPC2) by a team of astronomers led by Arsen Hajian of the U.S. Naval Observatory in Washington, DC. The Hubble Heritage team, working at the Space Telescope Science Institute in Baltimore, has prepared this color rendition by combining the Hajian team's WFPC2 images taken through three different color filters that isolate nebular gases of different temperatures.

The nebula shows several remarkable and poorly understood features. Blue regions mark the hottest glowing gas, which forms a roughly circular ring around the central stellar remnant. Orange and red show the locations of cooler gas. The cool gas tends to lie in long streamers pointing away from the central star, and in a surrounding, tattered-looking ring at the outer edge of the nebula. The origin of these cooler clouds within the nebula is still uncertain, but the streamers are clear evidence that their shapes are affected by radiation and stellar winds from the hot star at the center. The star's surface temperature is estimated at a scorching 140,000 degrees Celsius (250,000 degrees Fahrenheit).

Hajian and his team are scheduled to reobserve NGC 6751 with Hubble's WFPC2 in 2001. Due to the expansion of the nebula, at a speed of about 40 kilometers per second (25 miles per second), the high resolution of Hubble's camera will reveal the slight increase in the size of the nebula since 1998. This measurement will allow the astronomers to calculate an accurate distance to NGC 6751. In the meantime, current estimates are that NGC 6751 is roughly 6,500 light-years from Earth. The nebula's diameter is 0.8 light-years, some 600 times the diameter of our own solar system.

Image Credit: NASA and The Hubble Heritage Team (STScI/AURA)
Acknowledgment: A. Hajian (US Naval Observatory) andB. Balick (University of Washington)

home caption fast facts biographies

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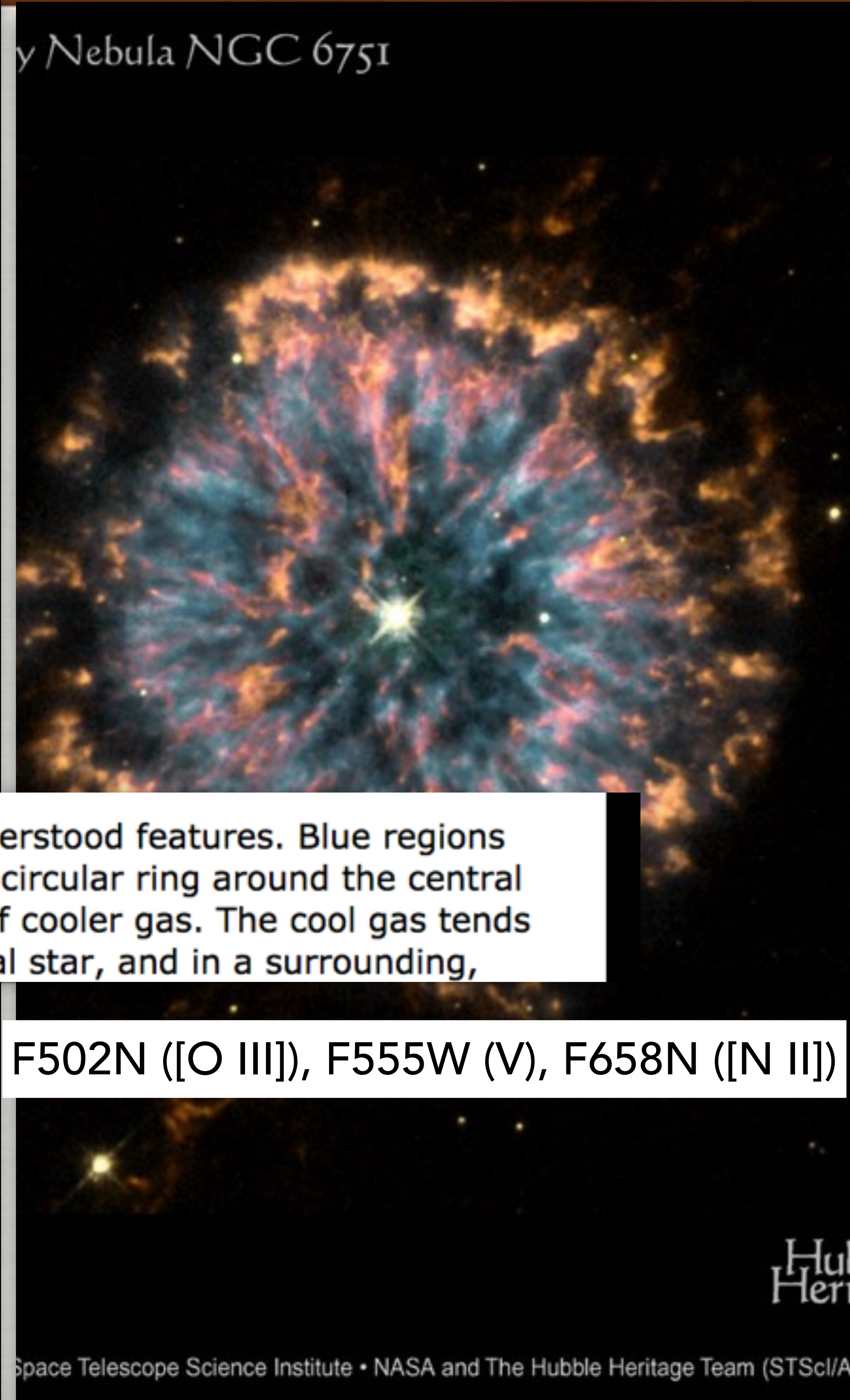
Image Credit: NASA and The Hubble Heritage Team (STScI/AURA)
Acknowledgment: A. Hajian (US Naval Observatory) andB. Balick (University of Washington)



F502N ([O III]), F555W (V), F658N ([N II])

TAKE HOME MESSAGE

IFS or 3D spectroscopic observations are very useful…

… BUT is you are dealing with a single **resolved object**, DO NOT try to understand it (especially any gradient of any observable) using integrated models.

Prefer trying to use a **spatially resolved model.**