3D Optical Spectroscopic Study of NGC 3344 with SITELLE: I. Identification and Confirmation of Supernova Remnants

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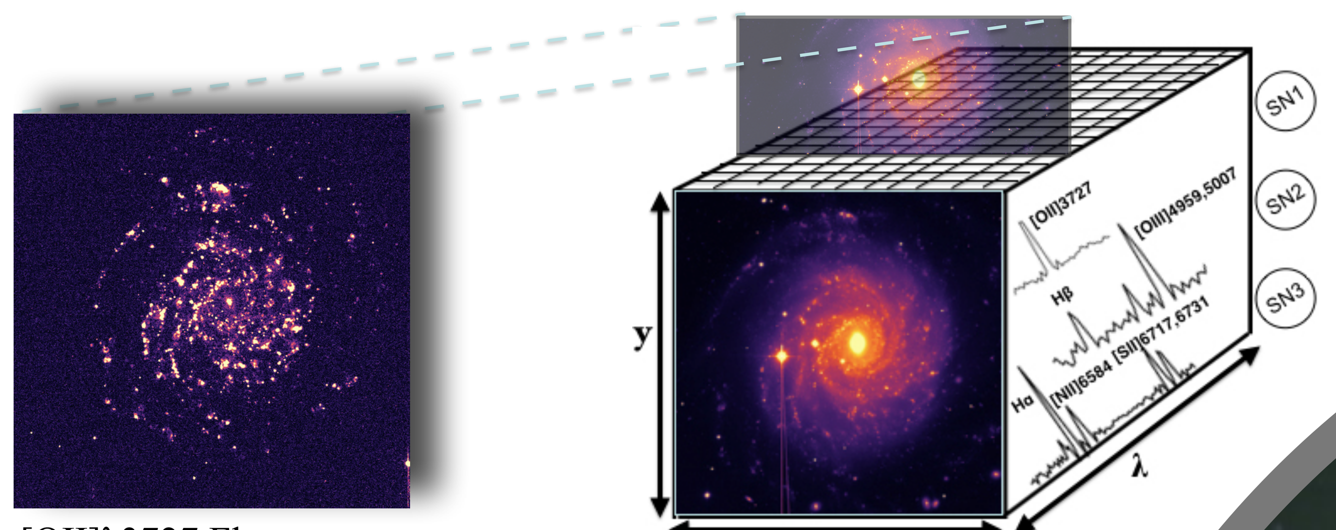
Abstract: In this poster, we present a SITELLE optical identification and confirmation of a large sample of Supernova Remnant (SNR) candidates in the nearby spiral galaxy NGC 3344. SITELLE, the imaging Fourier transform spectrograph of the Canada-France-Hawaii Telescope (CFHT), provides spectroscopic capabilities in the visible (350 to 900 nm, with filters) with a large field of view (11'x11') and a high spatial resolution (0.32" limited by the seeing), which are ideal to cover the whole disk of NGC 3344. Using 3 filters, we measured the strong emission lines [OII]λ3727, Hβ, [OIII]λλ4959,5007, Hα, [NII]λλ6548,6583, and [SII]λλ6717,6731. A sample of 129 SNR candidates have been identified based on four criteria that include the emission line ratio [SII]/Hα > 0.4. The whole set of emission lines have been used to describe the SNR properties and to confirm the shock-excited nature of these sources using a self-consistent spectroscopic analysis based on Sabbadin plots and BPT diagrams. With this analysis, we end up with 42 Confirmed SNRs, 45 Probable SNRs, and 42 Less likely SNRs. Using shock models, the Confirmed SNRs seems to have shock velocities below 250 km/s and a metallicity ranging between LMC and 2 x solar. A trend for a metallicity gradient was observed for the confirmed SNR.

1. Observation and Data Reduction

NGC 3344 was observed using the imaging Fourier transform spectrometer **SITELLE** (Drissen et al. 2019) installed on the 3.6-m CFHT. More than 4 million spectra have been obtained using the filters SN1 (365-385 nm, R≈400 in 2.8h), SN2 (480-520 nm, R≈600 in 3.1h), and SN3 (651-685 nm, R≈1500 in 2.7h) with an average spatial resolution of 0.8".

Data reduction was performed with **ORBS** (Outils de Reduction Binoculaire pour SpIOMM/SITELLE) and lines were fitted using **ORCS** (Outils de Réduction de Cubes Spectraux), two softwares developed specifically for SITELLE (Martin et al. 2015).



[OII]λ3727 Flux map

A 3D SITELLE Spectral datacube

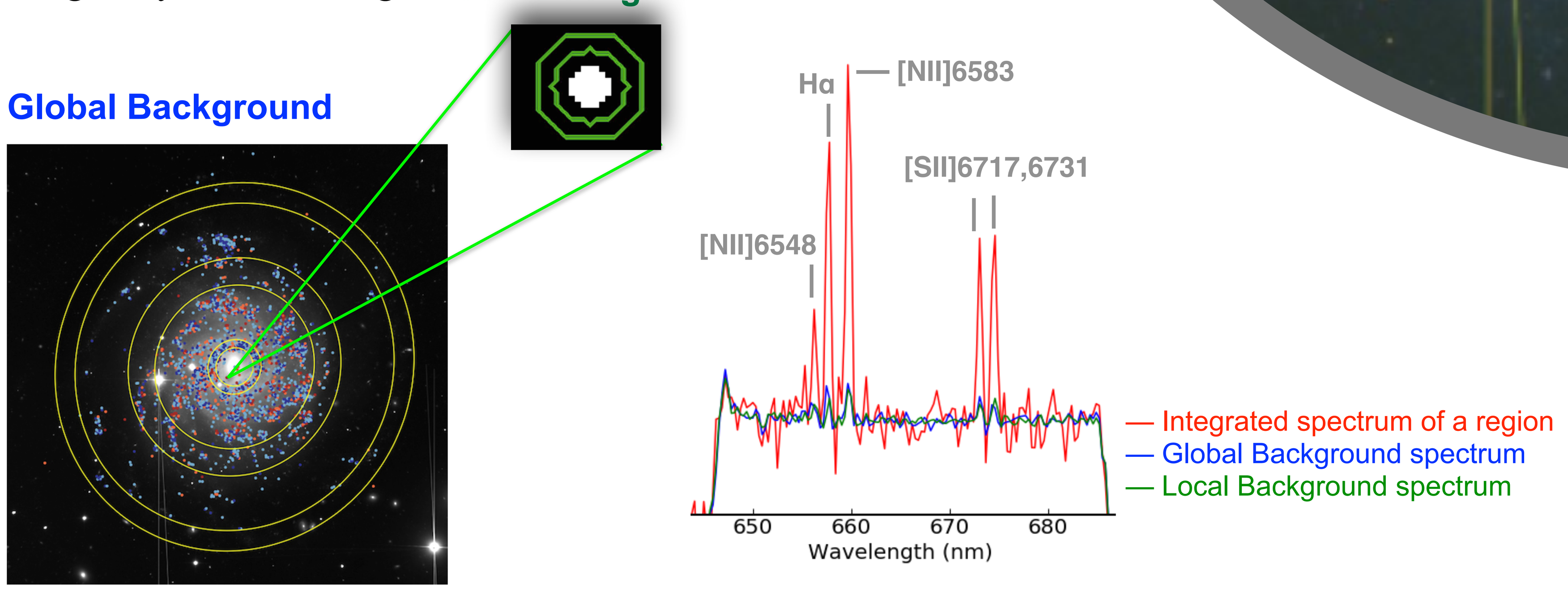
2. Background Subtraction

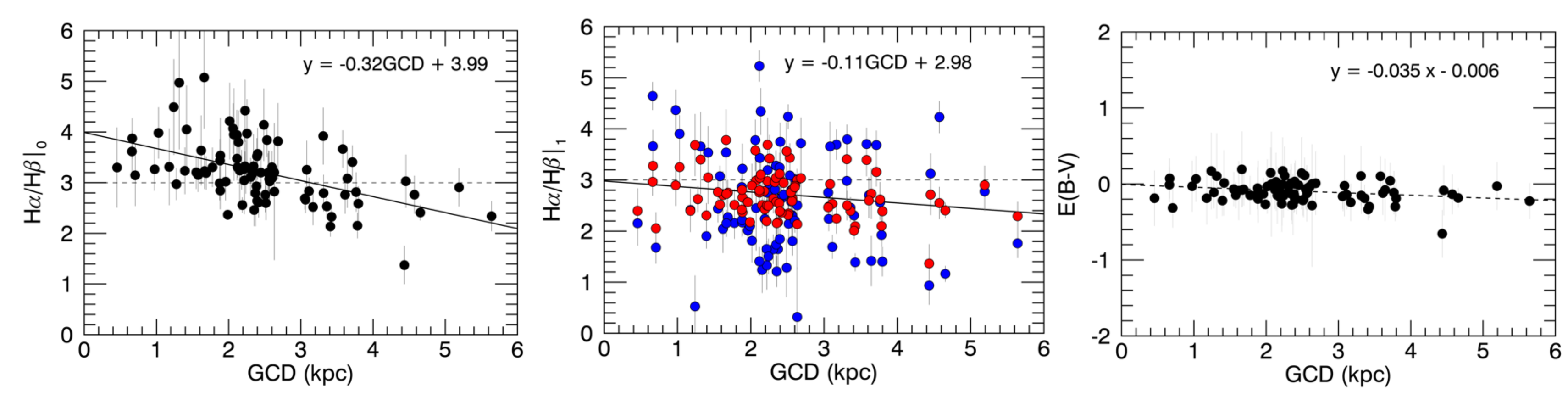
SITELLE reveals thousands of emission lines regions in NGC3344. These regions have been defined using the method of Rousseau-Nepton et al. (2018) for the [SII] emission peaks.

Depending on their locations, the regions spectra show an important contribution from the galaxy stellar populations and the diffused ionized gas (DIG).

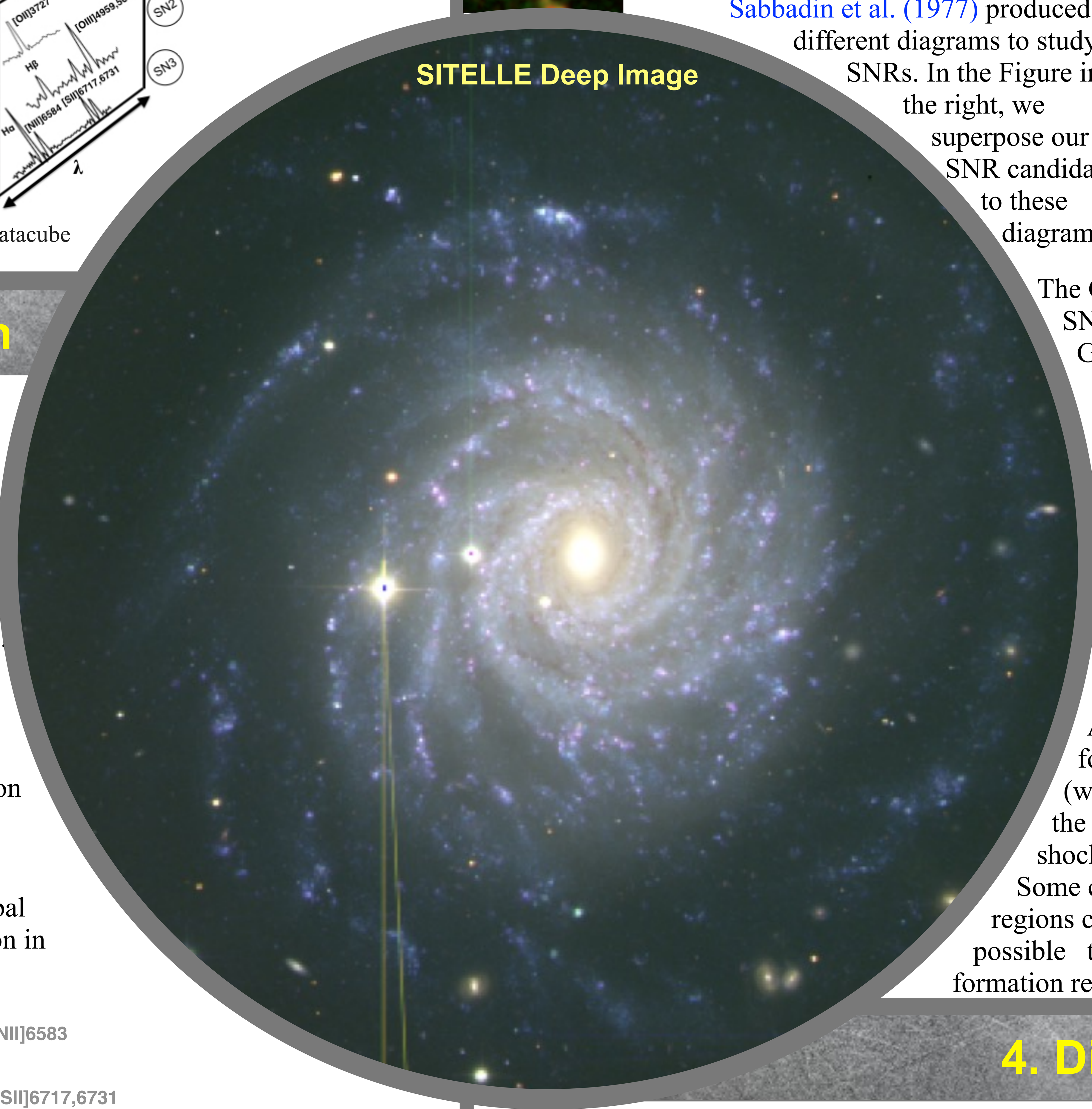
As shown in the following figures, two background geometries have been tested: (i) Global background using a ring centred on the galaxy nucleus; (ii) Local background with a ring centred on the region. Emission line regions have been masked in the rings and the thickness of the rings was chosen to reach a S/N≈25.

Although the difference is small, we adopted the Global background as it better represents the DIG contribution in the galaxy internal ring.



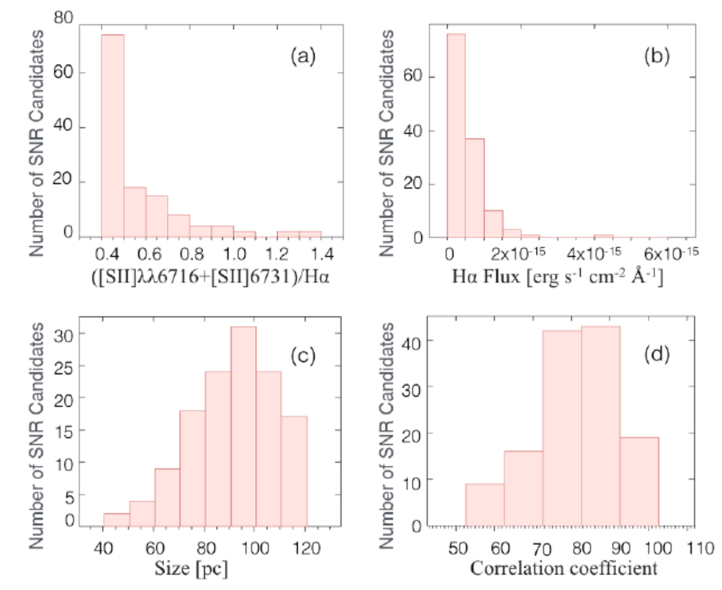


Comparison between **Global** and **Local** Backgrounds Impact on the Hα Amplitude.
Moumen et al. (submitted)

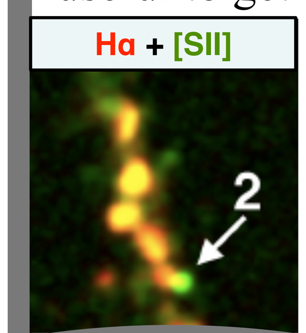


3. SNR Identification and Confirmation

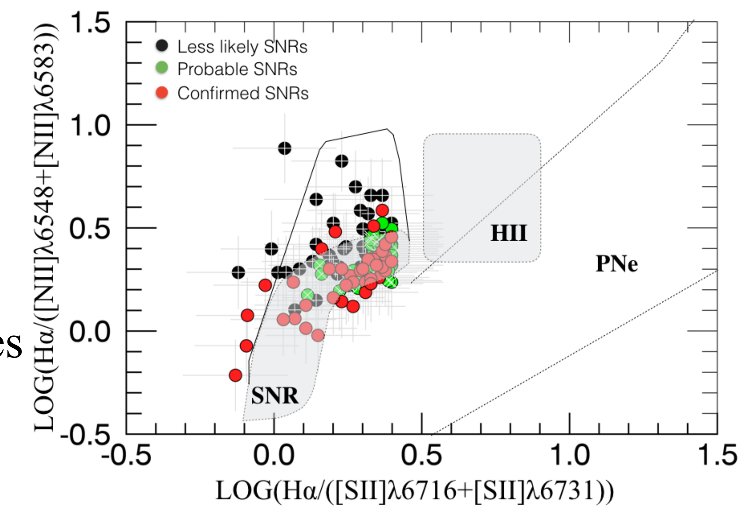
Four criteria were applied to select SNR candidates: (1) Line ratio [SII]/Hα ≥ 0.4; (2) The signal to noise ≥ 5 for Hα and [SII] lines; (3) The size of the region ≤ 120 pc; (4) The correlation coefficient of the profile ≥ 0.5.



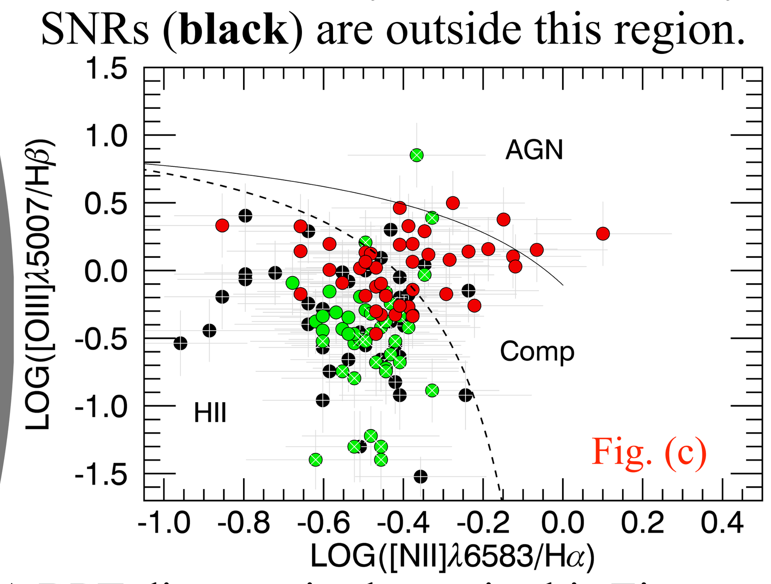
SITELLE provides important emission lines which are useful to get the gas physical parameters (e.g. [SII]/Hα and [OII] for the main shock heating mechanism, [NII]/Hα and [OII] for the metallicity, [OIII]/Hβ for the shock velocity, [SII] ratio for the density, Hα/Hb for the extinction, etc.).



Sabbadin et al. (1977) produced different diagrams to study SNRs. In the Figure in the right, we superpose our SNR candidates to these diagrams;



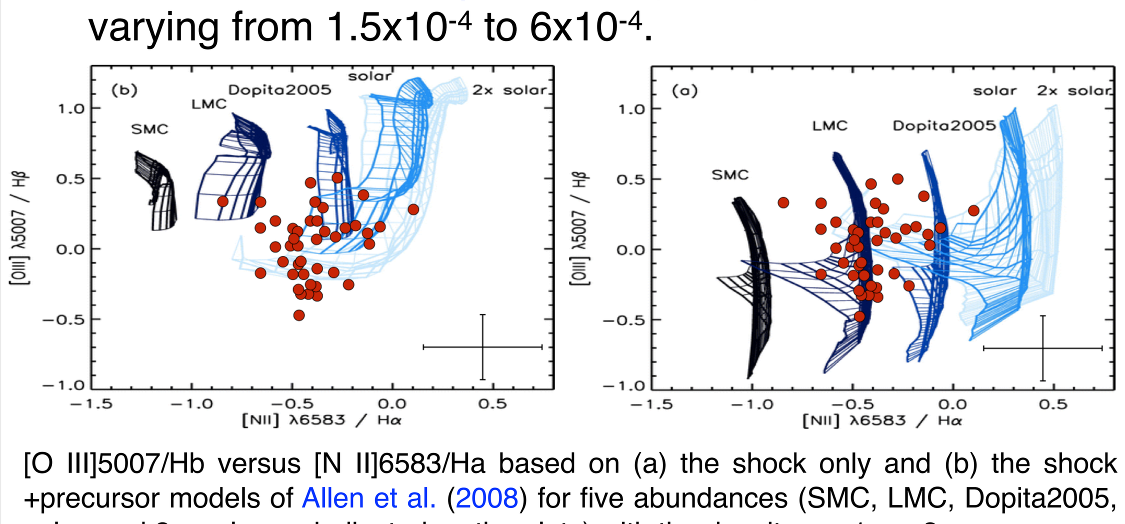
The Confirmed SNR (**red**) and the Probable SNRs (**green**) fall in the gray zone for the Galactic SNRs. Many of the Less Likely SNRs (**black**) are outside this region.



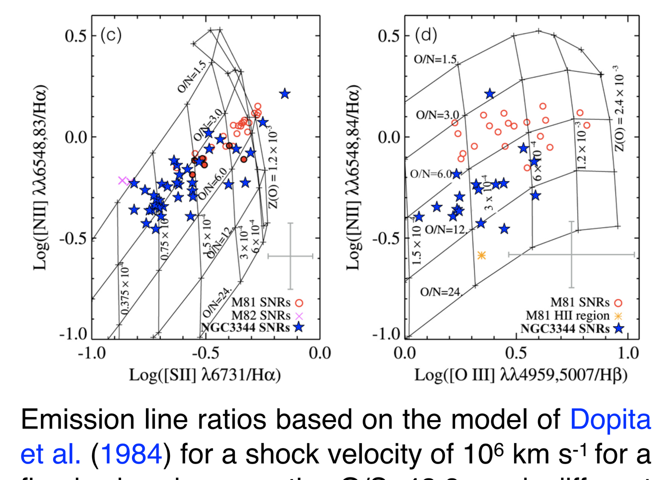
A BPT diagram is shown in this Figure for the whole sample of SNR candidates (with S/N > 3), which places most of the Confirmed SNRs in the zone for the shock-heated gas, over the HII regions zone. Some candidates may be DIG regions or HII regions contaminated by the DIG. It is also possible to have SNRs still buried into star formation regions.

4. Discussion

- We report the first identification and confirmation of a sample of SNRs in NGC3344. Our systematic analysis using physical, morphological, and spectral criteria reveals 129 SNR candidates which are classified in three categories: Confirmed (42), Probable (45), and Less likely (42) SNRs.
- We present a self-consistent spectroscopic analysis, exploiting all the emission lines available with SITELLE and using the Sabbadin plots and BPT diagrams, to confirm the shock-heated nature of the ionization mechanism in the SNR candidates. Eventually, the [OI]6300 line should be added to this analysis, allowing to consider (i) the [OI]6300 emission as another tracer of SNRs and (ii) the BPT-OI diagram to complete the available list of diagrams confirming the mechanisms of ionization in the optical range.
- We have compared shock models from Allen et al. (2008) with our emission line ratios obtained for the Confirmed SNRs. A metallicity ranging between LMC and 2solar and a low shock velocity below 250 km s^{-1} are then prescribed for these objects. A comparison with the shock models of Dopita et al. (1984) reveal an O/N abundance between 6 and 12 and Z(O) varying from $1.5x10^{-4}$ to $6x10^{-4}$.



[O III]5007/Hb versus [N II]6583/Ha based on (a) the shock only and (b) the shock +precursor models of Allen et al. (2008) for five abundances (SMC, LMC, Dopita2005, solar, and 2 x solar, as indicated on the plots) with the density n = 1 cm-3.



Emission line ratios based on the model of Dopita et al. (1984) for a shock velocity of 10^6 km s^{-1} for a fixed abundance ratio O/S=42.8 and different values of O/N and Z(O).

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