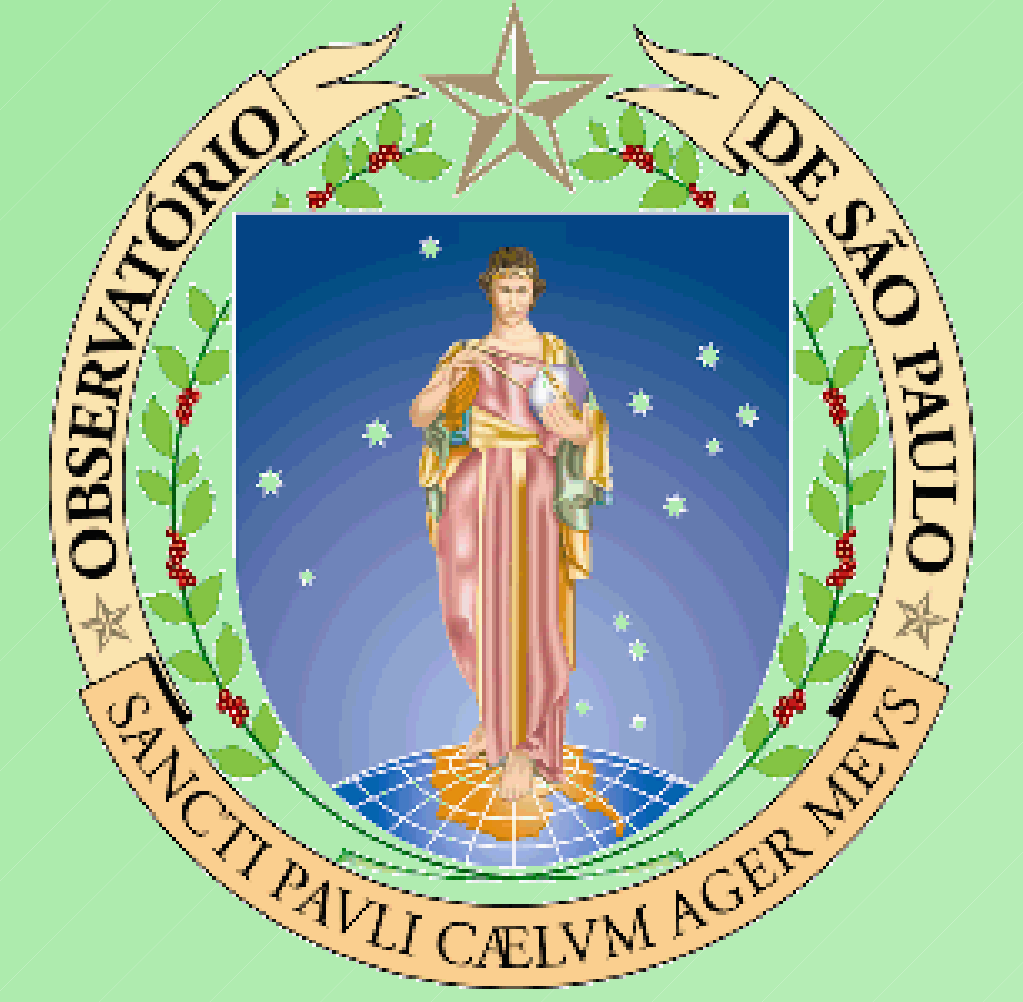# Detection and Characterization of Low Luminosities AGN in Nearby Early- type Galaxies

T.V. Ricci[1]*, J.E. Steiner[1], R.B. Menezes[1]

1 - Instituto de Astronomia, Geofísica e Ciências Atmosféricas – Universidade de São Paulo, Brazil

* tiago@astro.iag.usp.br

I – Introduction

• Active galactic nuclei (AGN) are usually associated to the capture of gas by a supermassive black hole, located at the center of most massive galaxies.
• Characterized by strong and broad emission line features in the optical region.
• Low ionization nuclear emission regions (LINERs).
  - Most common type of AGN.
  - Prominence of low ionization lines in the optical spectra.
  - More likely to be found in Early-type galaxies (Ho et al, 2008).
• We observed a sample of 10 Early type galaxies, closer than 30 Mpc and with high velocity dispersion ($\sigma > 200 km\ s^{-1}$) in order to detect and characterize low luminosity AGN (LLAGN).

II – Methodology

• Data cubes – observed with GMOS – IFU in Gemini South Telescope.
• Basic reduction steps performed (bias, flat-field, wavelength calibration and flux calibration).
• High frequency artifacts removal - low-pass Butterworth filter.
• PCA Tomography (Steiner et al, 2009) – search for spectro-spatial correlations in data cubes.
  Results:
    - Eigenspectra: correlations between wavelengths.
    - Tomograms: projection of the eigenspectra in the spatial dimension.
  Usage:
    - Removal of low frequency instrumental fingerprints (Steiner et al, 2012 – in preparation).
    - For scientific analysis purposes (e.g. Ricci et al, 2011; Schnorr Müller et al 2011).

• Richardson-Lucy deconvolution - 6 iterations in each data cube.
• Stellar spectral synthesis and subtraction - STARLIGHT code (Cid Fernandes et al, 2005). Applied to each spaxel of the data cubes. Results in a data cube of gas lines only.

III – Results

• PCA Tomography
  Whole wavelength range
   - Eigenvectors 1 - galactic bulge, together with signs of emission lines in some galaxies (e.g. IC 1459). Fig. 1: The 8 line emitting galaxies of the sample.

   - Eigenvectors 2 - correlation between emission lines in eight galaxies (Fig. 1). Tomograms are characterized by a point-like source (Fig. 2 – Green). We interpret these results as low luminosity AGN.
   - NGC 1399 and NGC 1404: no sign of AGN with the PCA Tomography.
  Wavelength range 6250 – 6800 A
   - This spectral region is dominated by emission lines.
   - Anti-correlation between the red and the blue components of the emission lines in 7 galaxies (two examples in Fig 3).
   - Tomograms (Fig. 2) - bipolar feature, where each component is anti-correlated with each other.
   - We propose that it is gas rotating disks.
  Wavelength range 5100 – 6200 A
   - Stellar components are more prominent.
   - Anti-correlation between the red and blue components of stellar lines in 6 galaxies (Fig 3).
   - Tomograms (Fig. 2) - bipolar feature, where each component is anti-correlated with each other.
   - Interpretation - stellar rotating disks.
• Gas data cubes
  Gas spectra from the nuclear region of the galaxies
   - Confirms the LLAGN of those 8 galaxies.
   - Line ratios: typical of LINERs.
   - NGC 1399 and NGC 1404 - Hα + [N II] feature in its gas spectra (Fig. 4).
   - Five galaxies: broad component in the Hα line. Example: IC 1459 (Fig. 4).
   - [O I] Broad component in four of the five galaxies above. Same FWHM as Hα. Example: IC 1459 (Fig. 4).
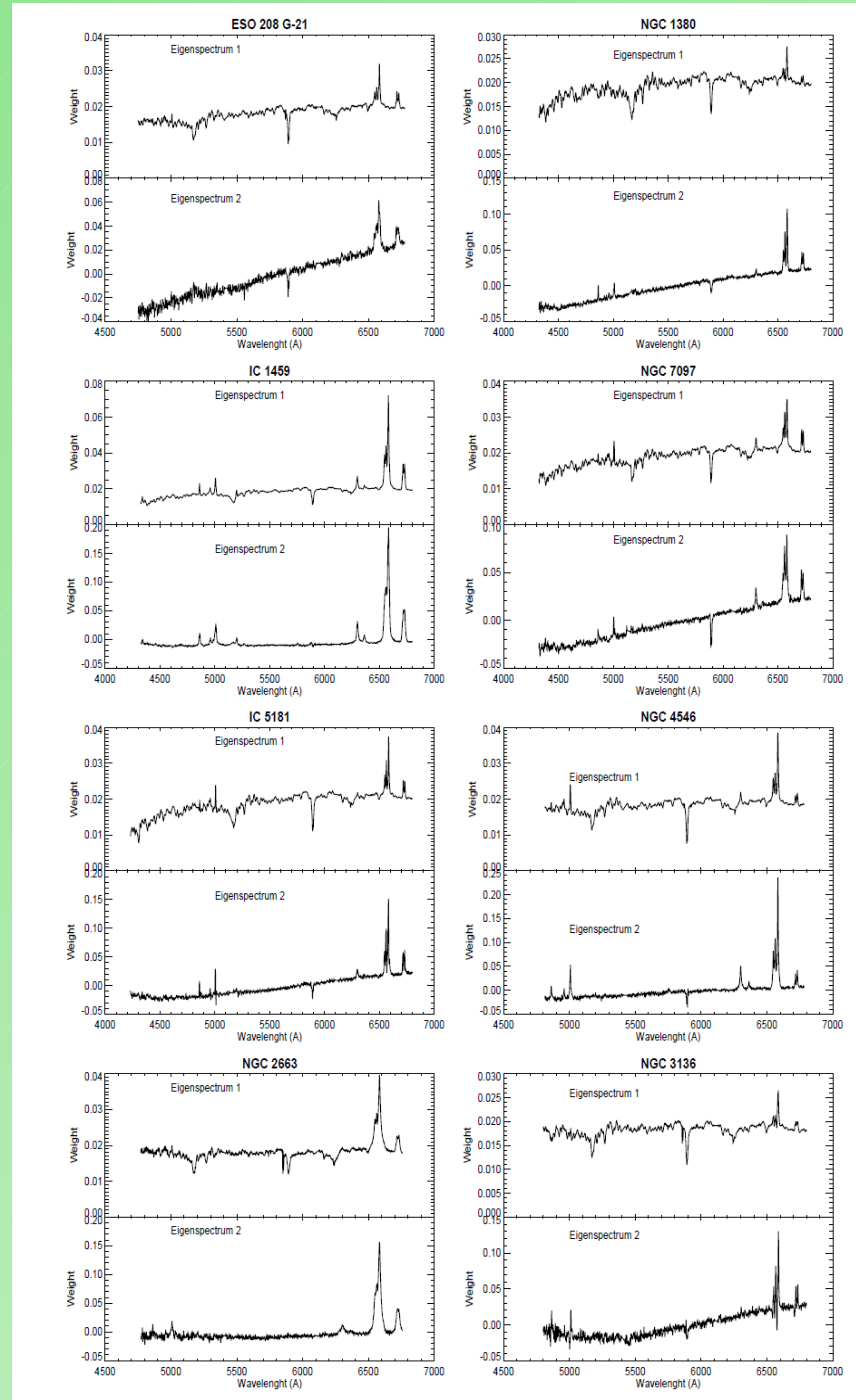

Figure 1 – Eigenspectra 1 and 2 from the PCA Tomography applied to 8 line emitting galaxies. The first eigenspectra correspond to the galactic bulges. The second ones are characterized by LINER type emission. One can see that the PCA Tomography is able to isolate the AGN effectively.
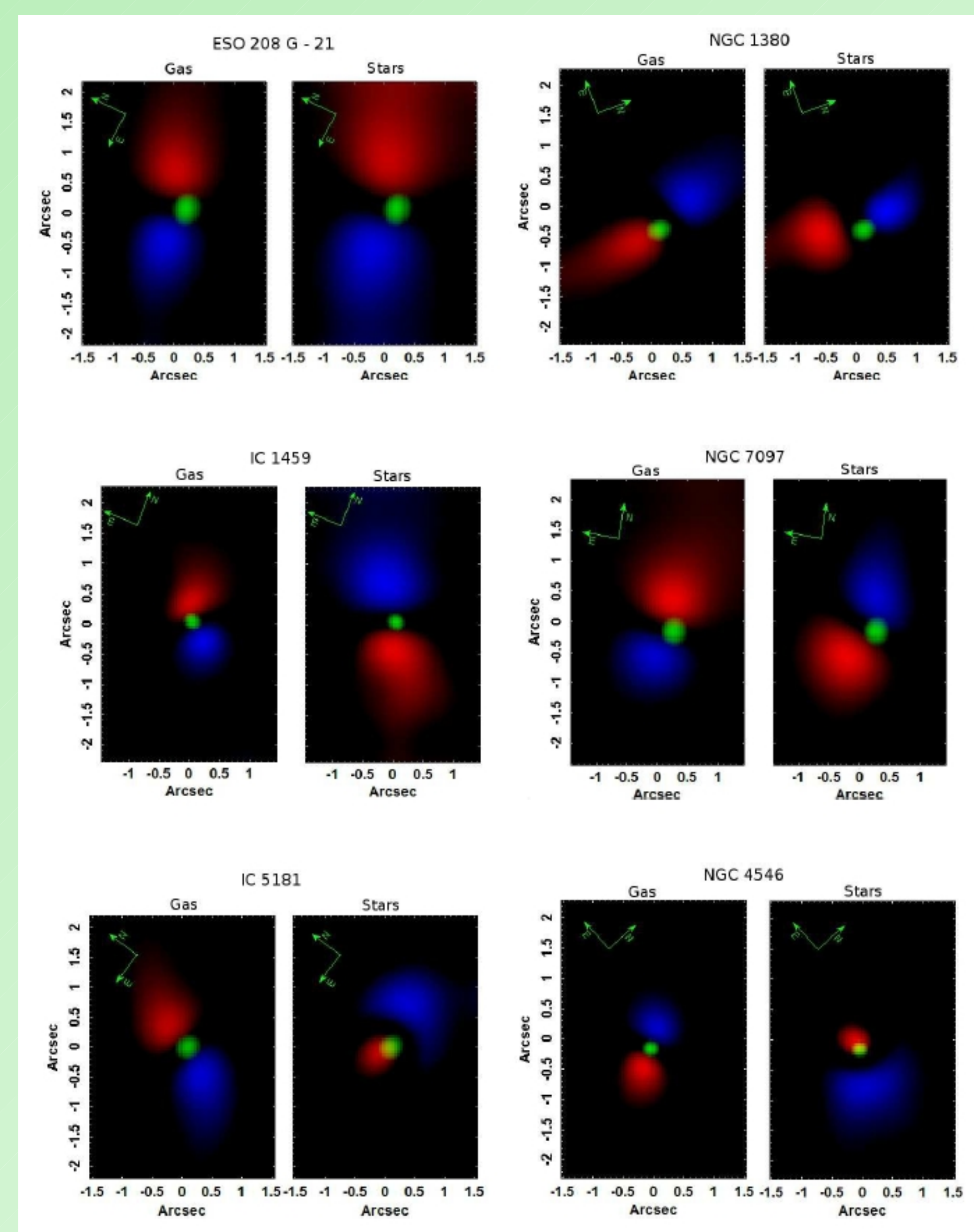

Figure 2 – Tomograms representing the gas and stellar rotation in 6 galaxies of the sample. The red and blue features correspond, respectively, to the red-shifted and blue-shifted components of the stellar/gas disks. The green component is the tomogram associated to the AGN, whose eigenspectra are seen in Figure 1. NGC 2663, whose galaxy only has a gas disk but not a stellar disk, is not shown in this Figure, but it has the same tomogram structure of the others.
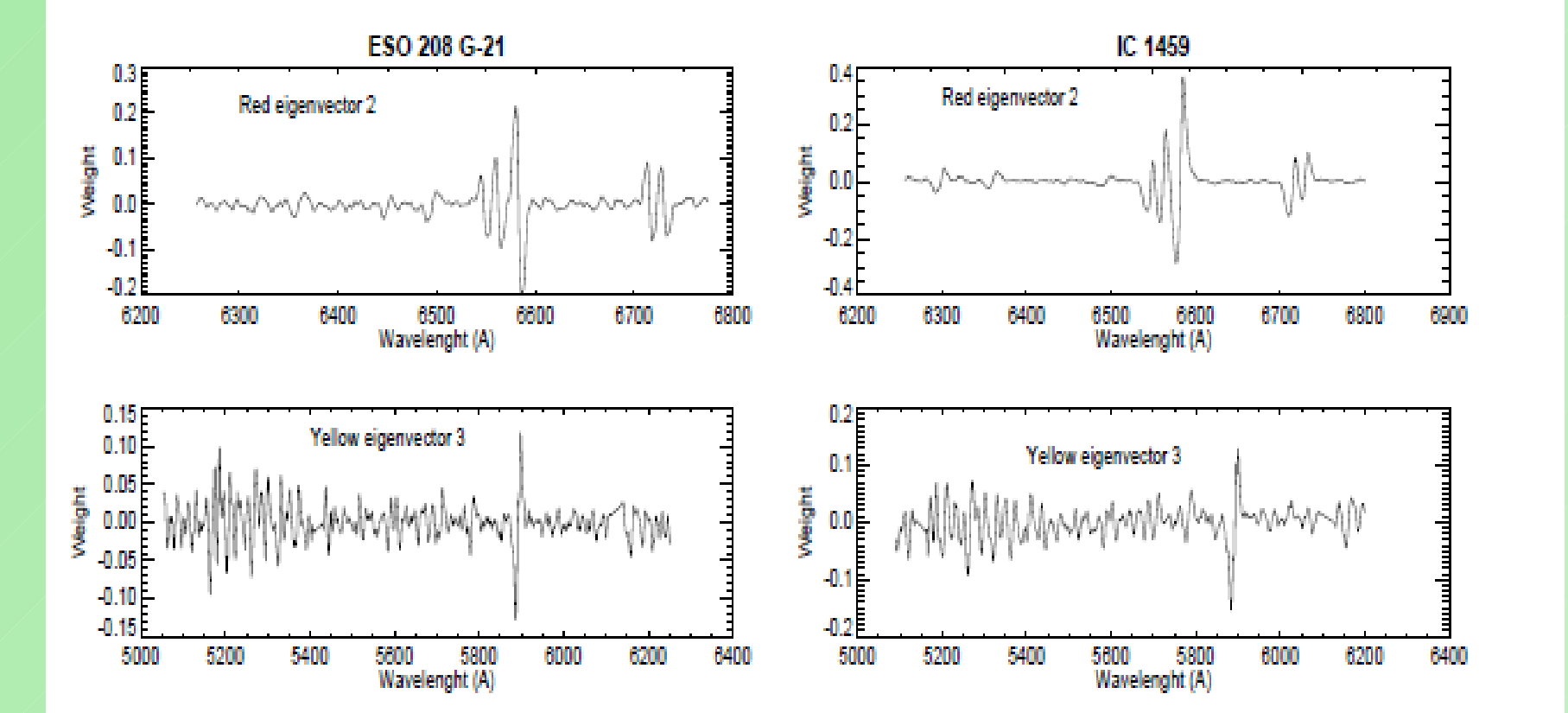

Figure 3 – Eigenspectra displaying the kinematic signatures of a gas (red eigenspectrum) and stellar (yellow eigenspectrum) rotation disks. The red eigenspectra correspond to the PCA Tomography applied on the data cube in the range 6250 – 6800 A, where emission lines dominate the spectra. The yellow eigenspectra are the results of the PCA Tomography applied to the data cubes in the range 5100 – 6200 A, where stellar lines dominate the spectra.
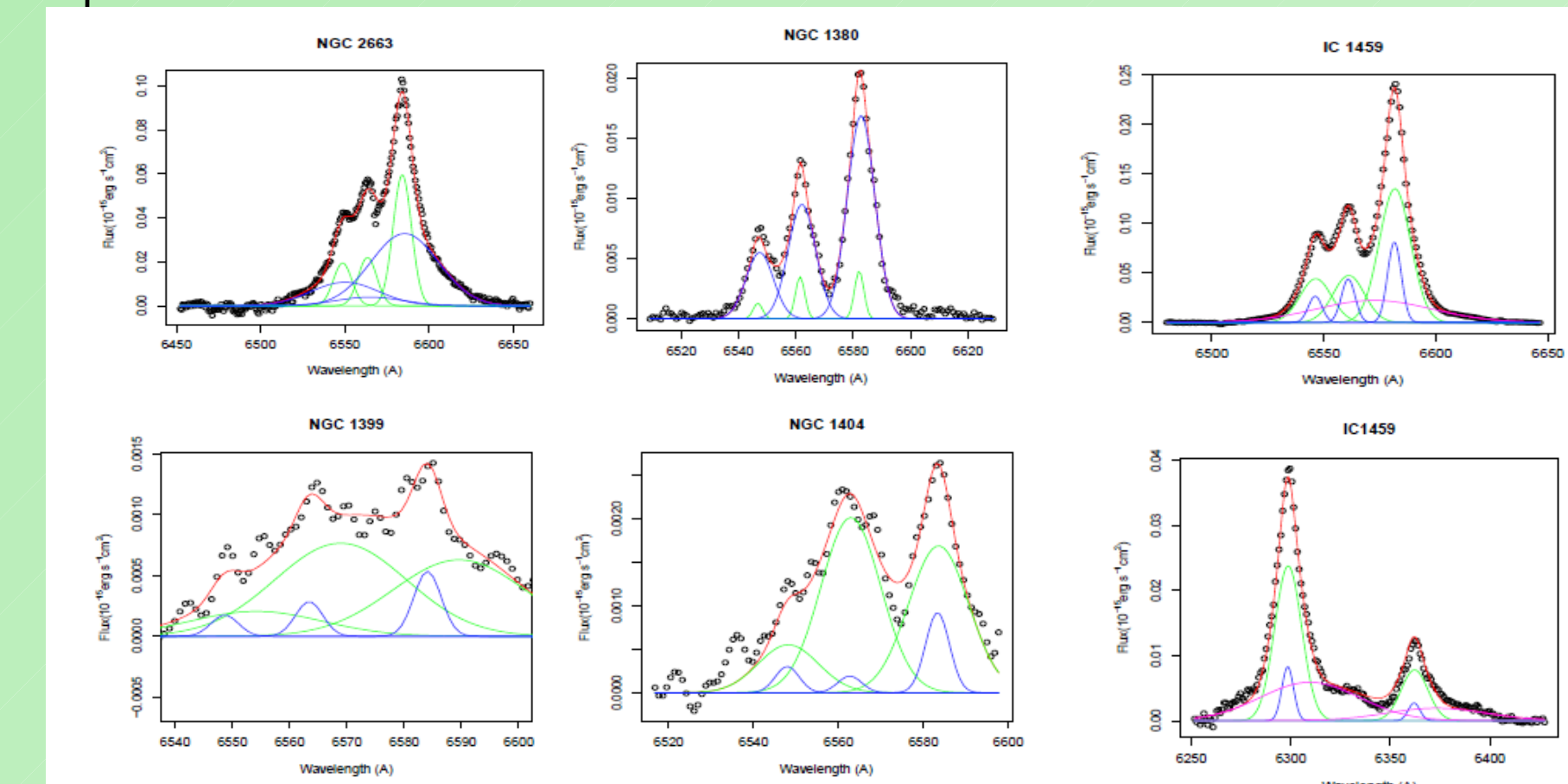

Figure 4 – Spectra extracted from the central region of the data cubes of gas only. Top left: NGC 2663. Two gaussians are fitted to the narrow component, but unusually broad (560 and 2160 km s⁻¹). Top center: NGC 1380, where we adjusted only the narrow component of each line with 2 gaussians. Top and botton right: IC 1459, where we adjusted 2 gaussians for each narrow component and one gaussian for the broad Hα component. The [O I] line also has a broad component, with the same FWHM of the Hα broad component. Bottom left and center: NGC 1399 and NGC 1404. The Hα + [N II] feature is detected in both galaxies, although the PCA Tomography didn't detect any sign of the AGN, probably because of their very low luminosity.

IV – Conclusions

• We detected 8 LINER type AGN in a sample of 10 Early- type galaxies using the PCA Tomography technique.
• In NGC 1399 and NGC 1404, the Hα + [N II] feature is detected only in the gas spectra. It indicates that they have very low luminosity AGN, probably LINERs too.
• PCA Tomography revealed gas rotation disks in 7 galaxies of the sample.
• In the 7 galaxies with gas disks, six also possess stellar rotation disks; we found that both disks are co-rotating in 2 galaxies, counter-rotating in other 2 galaxies and rotating in different position angles in the two remaining.
• NGC 2663 has a gas disk, but does not show any sign of a stellar disk.
• The detection of a broad component in the [O I] line suggests that the broad line regions of some LINERs have a density of the order $10^6\ cm^{-3}$.

·V – References

• [1] Cid Fernandes R., Mateus, A., Sodré L., Stasinska G., Gomes J.M., 2005, MNRAS, 358, 363
• [2] Ho, L. C., 2008, ARA&A, 46, 475
• [3] Ricci, T.V., Steiner, J.E., Menezes, R.B., 2011, ApJL, 734, L10
• [4] Schnorr Müller, Allan; Storchi-Bergmann, Thaisa; Riffel, Rogemar A.; Ferrari, Fabricio; Steiner, J. E.; Axon, David J.; Robinson, Andrew, 2011, MNRAS, 413, 149
• [5] Steiner, J.E., Menezes, R.B., Ricci, T.V., Oliveira, A.S., 2009, MNRAS, 395, 64