AGNIFS survey of local AGN: GMOS-IFU data and outflows in 30 sources

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ABSTRACT

We analyse optical datacubes of the inner kiloparsec of 30 local (\(z \leq 0.02\)) active galactic nuclei (AGN) hosts that our research group, AGNIFS, has collected over the past decade via observations with the integral field units of the Gemini Multi-Object Spectrographs. Spatial resolutions range between 50 pc and 300 pc and spectral coverage is from 4800 Å or 5600 Å to 7000 Å, at velocity resolutions of \(\approx 50\) km s\(^{-1}\). We derive maps of the gas excitation and kinematics, determine the AGN ionisation axis – which has random orientation relative to the galaxy, and the kinematic major axes of the emitting gas. We find that rotation dominates the gas kinematics in most cases, but is disturbed by the presence of inflows and outflows. Outflows have been found in 21 nuclei, usually along the ionisation axis. The gas velocity dispersion is traced by \(W_{80}\) (velocity width encompassing 80 per cent of the line flux), adopted as a tracer of outflows. In 7 sources \(W_{80}\) is enhanced perpendicularly to the ionisation axis, indicating lateral expansion of the outflow. We have estimated mass-outflow rates \(\dot{M}\) and powers \(\dot{E}\), finding median values of \(\log [\dot{M}/(M_\odot\,\text{yr}^{-1})] = -2.1^{+1.9}_{-1.0}\) and \(\log [\dot{E}/(\text{erg s}^{-1})] = 38.5^{+1.8}_{-0.9}\), respectively. Both quantities show a mild correlation with the AGN luminosity \(L_{\text{AGN}}\). \(\dot{E}\) is of the order of 0.01 \(L_{\text{AGN}}\) for 4 sources, but much lower for the majority (9) of the sources, with a median value of \(\log [\dot{E}/L_{\text{AGN}}] = -5.34^{+3.2}_{-0.2}\), indicating that typical outflows in the local Universe are unlikely to significantly impact their host galaxy evolution.

Key words: active galactic nuclei; galaxies: active; galaxies: nuclei; galaxies: kinematics; galaxies: Seyfert

1 INTRODUCTION

The discovery of correlations between the mass of the central supermassive black hole (SMBH) and various properties of the host galaxy, such as the host spheroid mass and stellar velocity dispersion (Ferrarese & Merritt 2000; Gebhardt et al. 2000; Gültekin et al. 2009; Kormendy & Ho 2013; van den Bosch 2016), or the similar evolution of the cosmic star formation rate (SFR) density and the black hole accretion rate density (Madau & Dickinson 2014) points to the growth of SMBHs being closely linked to the stellar mass assembly of their host galaxies. It is believed that this link emerges due to both the mass transfer to the inner region of the galaxy that also feeds the SMBH (Storchi-Bergmann & Schnorr-Müller 2019) and the regulating effect of feedback from the triggered active galactic nuclei (AGN) on the...
star formation in the host galaxy (Harrison 2017). The role of AGN feedback is supported by cosmological simulations and models of galaxy evolution (Springel et al. 2005; Vogelsberger et al. 2014; Schaye et al. 2015): feedback is required to reproduce observables such as the shape of the galaxy luminosity function, the colour bimodality of the galaxy population in the local Universe, and the low star formation efficiency in the most massive galaxies (Alexander & Hickox 2012; Fabian 2012; Harrison 2017).

AGN feedback consists of the injection of mechanical energy (through radio jets) and/or radiative energy (through accretion radiation coupling the gas to small scales and launching outflows) on the host interstellar and circumgalactic medium by the AGN. These two modes of energy injection are referred to as mechanical and radiative AGN feedback, respectively. Examples of mechanical AGN feedback in action have been found in dense environments in the local Universe, i.e. in the surroundings of elliptical galaxies in the centres of galaxy groups and clusters, where radio jets driven by low-luminosity AGN activity heat the circumgalactic medium through the injection of mechanical energy, reducing the cooling rate of the hot gas and maintaining star formation in the central galaxy at low levels (McNamara & Nulsen 2012). Radiative AGN feedback, on the other hand, has been mostly associated with luminous AGN (i.e. Quasars, $L_X \gtrsim 10^{45}\text{ erg s}^{-1}$) at intermediate to high redshifts ($z \gtrsim 0.5$), where galaxy-wide AGN-driven winds (with typical extensions of 1–10 kpc) have been observed both in warm ionised and cold molecular gas (Cicone et al. 2014; Harrison 2014; Leung et al. 2017; Vayner et al. 2017; Davies et al. 2020; Herrera-Camus et al. 2019). These winds can sweep away or heat up large amounts of gas, shutting off star formation in the host galaxy Dall’AgnoL de Oliveira et al. (2021).

A number of studies focusing on the star formation properties of Quasars, however, paint a different picture: Quasars are found to have similar star formation rates to main sequence galaxies at the same redshift (Harrison et al. 2012; Stanley et al. 2015; Schulze et al. 2019; Ramasawmy et al. 2019), implying no evidence of enhancement or suppression of star formation. These apparently conflicting results can be reconciled if the time scale for suppression of star-formation is longer than the time-scale of AGN activity (Hickox et al. 2014; Harrison et al. 2019). In this case, theoretical predictions will need to be combined with observations to identify the effects of AGN feedback (see Scholtz et al. 2018 for a discussion). Thus, it is critical to constrain how the energy radiated by the AGN couples to the host interstellar medium and determine the efficiency of this coupling, so that AGN feedback is properly implemented in numerical simulations and semi-analytical models.

While the most energetic AGN-driven winds are observed in distant Quasars, they are not the most adequate targets to quantify the impact of AGN radiative feedback on the evolution of the general galaxy population. This is because Quasars are not representative of the bulk of the AGN population, which is comprised mainly of moderate luminosity AGNs ($L_X \approx 10^{42} - 10^{44} \text{ erg s}^{-1}$, i.e. Seyfert galaxies), as evidenced by high-redshift X-Ray surveys (Brandt & Alexander 2015). Ideally one should study AGNs with redshifts in the range $z \sim 1$–3, as this is the epoch where both the star formation rate density and black hole accretion density peak. However, this is not feasible, as in moderate luminosity AGNs winds typically do not extend beyond the inner 1 kpc, so they would be unresolved with current observational facilities. It is thus necessary to find local Universe analogues that still serve as subjects for the study of feedback mechanisms.

In order to be able to resolve the inner kpc of moderately active galaxies, our group AGNIFS (AGN Integral Field Spectroscopy) has observed over the years several AGN hosts using Gemini IFS in the optical (e.g. Fathi et al. 2006; Storchi-Bergmann et al. 2007; Barbosa et al. 2009; Schnorr-Müller et al. 2014a; Lena et al. 2015; Schnorr-Müller et al. 2016, 2017a,b; Brum et al. 2017; Slater et al. 2018; Freitas et al. 2018; Humire et al. 2018; Muñoz-Vergara et al. 2019; Soto-Pinto et al. 2019) and in the near-IR (Storchi-Bergmann et al. 2009, 2010; Riffel et al. 2017, 2018; Schönell et al. 2019). While we have so far focused on individual galaxies, in this paper we present data for 30 objects observed in the optical using the Gemini Multi-Object Spectrograph Integral Field Unit (GMOS-IFU). For these we homogeneously derive maps of the gas emission-line fluxes, flux ratios and kinematic properties. Our main goal is to probe the gas excitation and kinematics within the inner kiloparsec of the host galaxies at spatial resolution down to tens to hundreds of parsecs in order to resolve the relevant processes of feeding and feedback of the AGN at the nucleus. In this first paper, we also report the values we have obtained for the galaxy photometric major axis, kinematic major axes of the gas and stellar kinematics, as well as mass-outflow rates and powers obtained from the measurements of emission-line profile widths at 80% intensity ($W_{80}$) when such values exceed 600 km s$^{-1}$. We also compare our results with those of previous studies relating these quantities to the AGN luminosity (e.g. Fiore et al. 2017).

This paper is structured as follows: in section 2 we discuss the sample, section 3 deals with the observations and data reduction procedures, emission line analysis and fitting is discussed in section 4, general results are shown in section 5, outflow estimates and comparison to AGN properties are shown in section 6 and finally we present our conclusions in section 7.

2 THE SAMPLE

The sample comprises 30 AGN, primarily in late-type galaxies, observed with the Gemini instruments GMOS-IFUs (North and South), between 2010 and 2017, and limited to a redshift of $z \lesssim 0.01$, except for three sources (Mrk 1058, Mrk 6 and Mrk 79) that are at $z \approx 0.02$. Out of the 30 galaxies in the sample, 22 have a counterpart in the 105 month Swift/BAT (hereafter SB105) catalogue (Oh et al. 2018). A target in our sample is considered to have a counterpart in SB105 if it lies within 15 arcmin of an X-Ray source. Incidentally, all the 22 counterparts in SB105 are classified as AGN. The remaining eight galaxies without a bright X-ray counterpart are either LINERS or Seyfert 2’s (Sy2). Figure 1 shows the location of our sample galaxies (blue stars) in the redshift-luminosity plane, along with other sources from the SB105 catalogue (grey circles). The 19 shared targets below $z=0.01$ in our sample correspond to nearly a third
of all Seyfert and LINER galaxies detected by Swift/BAT in that volume.

With the advent of recent surveys on black hole masses ($M_\bullet$) we can assess how well are we sampling the population of SMBHs in terms of their masses. In Figure 2 we compare the $M_\bullet$ distribution of our sample and the complete sample from van den Bosch (2016). We can see that, in comparison to that sample, our targets are lacking in the high mass end.

Basic properties of the galaxies studied in this paper are listed in Table 2. The nuclear activity type is based on Véron-Cetty & Véron (2010), and our reevaluation based on the nuclear spectra, where S1, S2, L1 and L2 represent Seyfert 1, Seyfert 2, Liner 1 and Liner 2, respectively. Most of the distances were taken from Tully et al. (2013), which is a compilation of measurements based on six different, redshift independent, methods. When more than one method was available, the average was adopted. No redshift independent distance method could be found for the galaxies MCG -05-23-015 and MCG -06-30-16; for these we based our distance calculation on the redshift with respect to the cosmic microwave background.

Projected scales were evaluated from the distances assuming the cosmological parameters from Hinshaw et al. (2012) ($H_0 = 69.32$ km s$^{-1}$ Mpc$^{-1}$, $\Omega_\Lambda = 0.7135$ and $\Omega_m = 1 - \Omega_\Lambda$) and a flat $\Lambda$CDM model. They range from 32 pc per arcsec for NGC 1566 up to 449 pc per arcsec for Mrk 1058. Regarding the environment, only two the galaxies in our sample are known to be interacting with another galaxy: NGC 3227 (Mundell et al. 2004) and NGC 3786 (Noordermeer et al. 2005). Additionally, the galaxy NGC 2110 shows a prominent dust lane, which may be an indication of a recent merger (Drake et al. 2003).

Finally, we point out that many galaxies in this sample have been individually presented in previous papers of the AGNIFS group, as pointed out in the Introduction. The main difference between those studies and the present paper is that here we performed an homogeneous analysis of the

![Figure 1. The location of the 22 galaxies of our sample which are listed in the Swift/BAT 105 month sample are shown as blue stars in this luminosity vs. redshift plane. Grey circles are Swift/BAT sources, blue stars are the 22 targets that overlap that sample in this paper.](image1.png)

![Figure 2. Histogram of the black hole masses of our sample galaxies compared to that compiled by van den Bosch (2016). Our sample shows a narrower distribution – covering masses in the range $10^6 - 10^{8.5}$ M$_\odot$ and missing the high mass end of the distribution ($10^{8.5} - 10^{10}$ M$_\odot$).](image2.png)

3 OBSERVATIONS AND DATA REDUCTION

3.1 Observations

The data used in this study comes from many observing runs, although with similar setups, obtained with the Gemini Multi-Object Spectrographs (GMOS) integral field units (IFUs) (Allington-Smith et al. 2002) both at the northern and southern Gemini telescopes. These IFUs consist of up to 1500 lenslets that feed the light, via fiber optic cables, to the diffraction grating. Each lenslet, which is hexagonal in shape, has a projected diameter in the plane of the sky of $0''18$.

GMOS has two modes of IFS observation: a “single slit” mode which provides a field of view (hereafter FoV) of $3.5 \times 5$ arcsec, and spectral coverage of $\sim 2000\AA$, and a “two slit” mode which trades roughly half the spectral coverage for a doubled FoV. The slits mentioned here are not actual slits, but rather the result of arranging the fibers in a straight line. In the single slit mode each exposure produces 500 on-sky spectra, and 250 sky spectra. The latter are used to remove atmospheric emission from the science spectra. These numbers are doubled in the two slit mode.

The gratings used in these observations, namely B600 and R400, have a resolving power of $R \sim 1800$, which translates to a velocity resolution of $\sim 50$ km s$^{-1}$. [O iii] and H$\beta$ lines are available only for the 13 galaxies of the sample.
observed in single slit mode, covering the wavelength range \( \approx 4800-7000\AA \), and identified in Table 2 with the symbol \( \dagger \) adjacent to its name while the remaining targets were observed in two-slit mode and have spectra in the range \( \approx 5600-7000\AA \). Angular resolutions vary between 0.06 and 1.0, depending on the seeing.

Figure 3 shows examples of the IFU’s FoV superimposed on the r band acquisition images. The bottom panel displays the nuclear spectrum of each galaxy, summed over a circular aperture with a 1 arcsec radius. The acquisition images with the superimposed IFU FoVs of all other galaxies in the sample are shown in Figure B1 of the Appendix B (available as online supplementary material).

3.2 Data reduction

Data reduction was based on the package provided by the Gemini observatory for IRAF. Additionally, we have developed a publicly available automated pipeline named gireds\(^1\) to process the raw data through the many tasks of the Gemini package, and also perform quality control checks along the reduction. The reduction follows standard procedures of bias subtraction, flat-fielding and wavelength calibration based on arc lamp spectra. Spectra from each fiber were extracted using apertures identified in the flat-field images, which were taken within two hours from the science images. Relative flux calibration was achieved using spectrophotometric stars observed in the same semester of the science observations, and the same instrumental setup.

In order to facilitate posterior analyses of the data cubes, GMOS’ original IFU matrix, which is composed of hexagonal lenses with a diameter of 0.18”, was interpolated into an image with square spaxels, each having a side of 0.1”. This process causes a minor oversampling of the data but allows the direct application of standard image analysis tools over the data cube. The task GFCUBE was used in re-sampling the data cube, which includes a correction for differential atmospheric refraction for each wavelength plane.

Gemini’s world coordinate system (WCS) uncertainty and repeatability is comparable to the IFU field of view (\( \sim 5 \) arcsec), thus one cannot rely on the WCS data for combining data cubes with spatial dithering. Since these observations were not performed using adaptive optics, the spatial resolution element is seeing limited to a FWHM of 0.06” at best. Therefore, registering of different exposures of the same galaxy based on the peak of continuum emission would most probably degrade the spatial resolution. The best re-

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\(^1\) https://github.com/danielrd6/gireds
results were achieved by combining data cubes from different observations based on instrumental offset coordinates.

3.3 Flux calibration

The majority of the data cubes in our sample do not have an associated observation of a standard spectro-photometric star. We therefore resorted to a method of absolute flux calibration based on the acquisition images. The method consists in matching stars of known magnitude, taken from an astrometric catalog, to point sources that appear within the field of view of the acquisition camera.

Acquisition images were first reduced using the Gemini IRAF package for GMOS image reduction. Using the Astrometry.net software (Lang et al. 2010), we have regenerated the astrometric calibration of each acquisition image, in order to ensure that we are matching the correct sources to the correct stars in the catalogue. Aperture photometry was performed using the PHOTUTILS package (Bradley et al. 2018), with stellar sources being identified by a Python implementation of the DAOFIND algorithm (Stetson 1987). Stellar magnitudes and positions were taken from the USNO-B catalogue (Monet et al. 2003), which has typical R band magnitude uncertainties of 0.25 mag. In principle, performing flux calibration with the acquisition images should account for all low frequency atmospheric effects, since the acquisition is taken within two hours or less of all the science exposures.

Zero point magnitudes for the acquisition images were evaluated as the median of equation 1 for all the \(i\) stellar sources identified in the acquisition image. Sources with FWHM which differed by more than 20% of the median FWHM were rejected. An iterative sigma-clipping algorithm was also used to reject outliers above the 3\(\sigma\) level.

\[
\mu_i = 2.512 \log I_i + m_i
\]

where \(\mu_i\) is the magnitude zero point, \(I_i\) is the background subtracted instrumental flux from the aperture photometry, and \(m_i\) is the magnitude in the USNO-B catalogue. Since all acquisition images were taken with the filters G0326 and G0303 (for Gemini’s South and North respectively), we chose to use the relatively similar R band magnitudes of USNO-B. The flux ratio between the Johnson R band and GMOS' filters are reasonably stable for a wide variety of stellar spectra, which we tested with the MILES library (Falcón-Barroso et al. 2011), with a standard deviation of 12 and 5 per cent for G0303 and G0326 respectively.

Once we have the estimate for the conversion of instrumental units to R band magnitudes, we proceeded to perform a spectrophotometric analysis of the data cube. A nuclear spectrum was extracted from the IFS data, using a circular aperture with 1 arcsec of radius, centred on the peak continuum emission. The equivalent R band magnitude of this spectrum was estimated by multiplying the spectrum by the filter transmission curve and integrating over wavelength. Comparing the latter to the magnitude obtained within an identical aperture in the acquisition image yielded a conversion factor from the relative flux to the absolute flux.
4 EMISSION LINE FITTING

The emission line measurements are based on the fit of a combination of Gauss-Hermite polynomials (van der Marel & Franx 1993; Riffel 2010) up to the fourth order with a number of constraints among related spectral lines. Gauss-Hermite polynomials have the advantage of reduced dimensionality in comparison to multi-component Gaussian fits. However the function itself is not physically motivated, and therefore the quantitative interpretation of the results is comparatively more complex. In addition to the amplitude, mean and standard deviation parameters of a single Gaussian curve, we fitted the coefficients $h_3$ and $h_4$ for the third and fourth order elements, respectively. The effect of the $h_3$ coefficient is to produce an asymmetric profile, with positive values having a blue wing, and negative values having a red wing. The $h_4$ profile, on the other hand, produces a symmetric effect of broadening the base of the profile for positive value, or the top for negative values. An example of such a fit and its interpretation in light of a double-gaussian profile is shown in Figure 4.

Profile fitting of emission lines was done by a in-house developed algorithm. This code is part of a Python based package of spectral analysis routines, named ifscube (Ruschel-Dutra & Dall’Agno de Oliveira 2020), which is publicly available on the internet. ifscube allows the fitting of Gaussian or Gauss-Hermite profiles, with or without constraints or bounds. The fitting algorithm includes integrated support for pixel-by-pixel uncertainties, weights and flags, subtraction of stellar population spectra, pseudo-continuum fitting, signal-to-noise ratio evaluation and equivalent width measurements. Model fitting relies on SCIPY’S (Virtanen et al. 2020) routines for non-linear numerical minimization. ifscube also supports user interaction via a human-readable configuration file, allowing even those that are unfamiliar with the Python language to use it. The stellar population contribution was fit to the spectrum with spectral synthesis code pPXF (Cappellari & Emsellem 2004; Cappellari 2017) and the MILES simple stellar population models (Vazdekis et al. 2010). For the few galaxies in which the signal-to-noise ratio in the stellar continuum was not high enough to reliably constrain the stellar population the continuum was represented by a smooth polynomial function.

In type 1 AGNs the broad component of the Hydrogen lines was fitted by a combination of three Gaussian curves, in tandem with two Gaussian curves for each of the narrow lines. The central wavelength, relative flux and width of each of the three Gaussian components was fit only once, using the summed spectrum of all the spaxels within 1 arcsec from the continuum centre. Since the broad H lines originate in the same unresolved source, we can apply the same model for all the spectra with the broad line contribution, with only a scaling factor for the flux. Having constrained the broad components in this way, the narrow components were fitted again over the whole datacube.

Figure 4 shows an example of the emission line modelling for the nuclear spectrum of NGC 2110. In this example each individual component is shown as a dashed black line and the observed spectrum, minus the stellar population, as a solid blue line. The broad Hα component was omitted here to emphasise the profiles of the narrow lines. A representation of the Gauss-Hermite polynomial fit in terms of a two component Gaussian model is shown in the inset at the upper right of Fig. 4.

Assuming the narrow line region to be in ionisation equilibrium, and to be well represented by the case B recombination scenario (Osterbrock & Ferland 2006), we imposed the corresponding constraint on the flux ratio of the [N H] lines $F[N H]/F[H 6583]=1/3$. Kinematic parameters for the [N H] and [S H] lines are kept the same, namely the velocities corresponding to the line centres and the velocity dispersion with respect to the rest frame, as well as the $h_3$ and $h_4$ parameters. These last two parameters were also limited to values between $-0.2$ and $+0.2$. When the blue portion of the spectrum was available, the following constraints were also used: fixed kinematics and between $[O III]$ lines and between Hα and Hβ, and also a fixed ratio of $f_{5800}/f_{2959} = 3$ for the $[O III]$ lines. The flux ratio between the $[S II]$ lines at $λλ 6716, 6731Å$ was constrained within the lower and upper electron density limits: $0.41 < f_{6716}/f_{6731} < 1.45$.

4.1 Velocity dispersion via $W_{50}$

Traditional quantities to represent the velocity dispersion of a quasi-Gaussian profile, such as the Gaussian σ or the FWHM, fail to capture the complex kinematic picture that is commonly encountered in AGN, in particular at high velocity dispersion. Therefore we employed the $W_{50}$ index (Zakamska & Greene 2014), which is the width, in velocity scale, that encompasses 80% of the flux of a given emission line. This index has the advantage of being independent from the assumed line profile, since it is measured directly on the observed profile. Assumptions about the line profile are only important when measuring the $W_{50}$ index of a blended line, as neighbouring lines have to be subtracted prior to the integration.

The $W_{50}$ evaluation begins with the subtraction of the continuum – the fitted stellar population templates or a local continuum in the cases we could not fit the stellar population – and also of neighbouring emission lines, when applicable. Then a cumulative integral is calculated and normalised, so that the $W_{50}$ will be the difference between the velocity at 90% and 10% of the total flux. The integration limits for the cumulative integral are set at $±5σ$ from the line centre, which was evaluated during the profile fitting process. For a Gaussian profile $W_{50}$ is about 10% larger than the FWHM, or $W_{50} = 2.56 × σ$. Normal rotation velocities and velocity dispersions for a galactic potential of even the most massive galaxies limits the $W_{50}$ to 600 km s$^{-1}$. Emission lines with $W_{50} > 600$ km s$^{-1}$ are therefore a signature of gas in unbound orbits, most probably (and assumed to be the case here) outflowing (e.g. Sun et al. 2017; Harrison 2014).

Some emission line profiles, most notably the Hydrogen lines of the Balmer series, are affected by the underlying stellar absorption, which influences both the flux and the centre of the ionised gas features. This has been taken care of with the fit and subtraction of the stellar population contribution, except for the Markarian galaxies for which the stellar continuum is too weak and this fit and subtraction was not possible. For these galaxies, with no stellar population subtraction, we impose a lower limit on the equivalent width of Hα emission of $W_{5}(Hα) > 6Å$ when estimating the Hα luminosities. The reason is that this value corresponds to approximately twice the maximum absorption $W_{5}(Hα)$
of any simple stellar population (e.g. Bruzual & Charlot 2003), thus corresponding to a possible maximum error of about 30% in the emission-line flux.

5 RESULTS

Results in the form of maps obtained from the emission line fits, as well as of some derived properties, are shown in Fig. 5, Figs. C1 to C30 of the Appendix and in Table 3. Fig. 5 is an example, showing the galaxy Mrk 348, with a spectral coverage of ≈4800–7000Å, however almost half of our sample is limited to the range ≈5600–7000Å. The former allows the mapping of the [O III] and Hβ emission-line properties besides those of Hα+[N II] and [S II] of the latter.

The maps in the above figures show: the flux distribution of a selected ionised gas emission line ([N II] and [O III] when available); the radial velocity of the ionised gas, given by the central wavelength of the emission line fit; the W50 map; the equivalent width of the narrow component of Hα; the flux ratios between [N II] ([O III] when available) and Hα (Hβ when available); and the electron density of the ionised gas. The latter is based on the flux ratio between the [S II] λ6716,6731Å lines (see section 6.4). All figures were rotated so that North is up and East is to the left. In order to remove high frequency noise from the images, we have convolved them with a 2D Gaussian kernel, with σ = 0.2 arcsec, corresponding to approximately the size of the lenslet in the IFU array, and two spaxels of the datacube. The cross in the centre of the images marks the peak of stellar continuum emission, which we adopted as corresponding to the galaxy nucleus. In order to better visualize the flux distributions of the emission lines, we have defined the “strong emission region” (SER) as that enclosed by an isophote with a flux level 1/10th of the peak flux; shown in the in the flux maps (upper left panel of the figures) as the dashed light green contour. Only continuously connected emitting regions with origin at the galactic nucleus are considered, thus excluding ionised gas clouds that are not directly connected to the nucleus.

We have also included in the figures a dashed red line showing the orientation of the photometric major axis (hereafter PMA) determined over a 2MASS K-band image except for the galaxies NGC 1068, NGC 1566, NGC 4593 which were individually evaluated based on DSS images, and NGC 5728 which follows Erwin (2004). The orientation of the PMA is also listed in Table 3.

The magenta dashed line in the figures shows the approximate direction of elongation of the area dominated by outflows when present, as visually inferred from the gas kinematic and flux distribution maps (these latter showing the orientation of the ionisation axis). The adopted outflow PA is listed in the 8th column of Table 4. In some cases for which there is no clear indication of outflow along the ionisation axis, but there is enhancement in W50 perpendicular to the ionisation axis, we have adopted this PA as corresponding to the outflow. We have also included in the W50 maps a dashed circle showing the distance at which we have calculated the mass-outflow rates and powers, which are also listed in the 2th and 4th columns of Table 4.

Table 3 also includes the kinematic major axis derived from the [NII] and [O III] velocity fields, which is represented by the blue continuous line in Fig. 5. Position angles for the kinematic axes were inferred based on the assumption of a symmetric velocity field, and using the fit_kinematic_PA code (Krajnovic et al. 2006). Although not as justifiable as in the [N II] case, assuming a symmetric [O III] velocity field is still informative for our purposes, if only in a comparative sense. Furthermore, a symmetric velocity field does not necessarily imply rotation, since it could also be the result of a biconical outflow. Fits of the [N II] velocity field were used to derive the gas systemic velocities of each galaxy, which were subtracted from the velocity maps and are listed in the second column of table 3. These same velocity field fits also give the kinematic major axis for each emission line (third and sixth columns).

We now discuss the global properties of the sample.

5.1 Flux maps and excitation

Inspection of the flux maps in Fig. 5 and Figs. C1 to C30 of the Appendix reveals extended emission over most of the FoV and some degree of collimation along a direction that we identify as the ionisation axis. The orientation of the ionisation axis varies; for the following 10 galaxies this orientation is similar to the PMA: Mrk 607, NGC 1365, NGC 1566, NGC 1667, NGC 2110, MCG-05-23-016, NGC 3516, NGC 3786, NGC 4593, MCG-06-30-015. Colimated gas emission along a direction distinct from that of the PMA is observed in 15 galaxies: Mrk 348, Mrk 1058, NGC 1068, NGC 1358, NGC 1386, Mrk 6, Mrk 79, NGC 2787, NGC 3081, NGC 3227, NGC 4501, NGC 5728, NGC 5899, NGC 6300, NGC 6814. In the case of the following 5 galaxies: NGC 3783, NGC 3982, NGC 4180, NGC 4450 and NGC 7213, the orientation of the ionisation axis is not clear.

The line ratios [O III]/Hβ and [N II]/Hα are all consistent with AGN excitation over most of the FoV. Only occasionally their values indicate that ionisation from young stars becomes dominant in the vicinity of the AGN (i.e. in the galaxies NGC 1566 and NGC 2110).
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Table 3. Velocities, kinematic and photometric major axis
Columns are: (1) name of the galaxy; (2) systemic velocity of the [N\text{II}] velocity field; (3) kinematic major axis of the [N\text{II}] velocity field; (4) [N\text{II}] ionisation axis; (5) systemic velocity of the [O\text{III}] velocity field; (6) kinematic major axis of the [O\text{III}] velocity field; (7) [O\text{III}] ionisation axis; (8) Photometric major axis;

| Galaxy     | [N\text{II}] v_{sys} km s^{-1} | KMA [N\text{II}] | [N\text{II}] IA | [O\text{III}] v_{sys} km s^{-1} | KMA [O\text{III}] | [O\text{III}] IA | PMA |
|------------|--------------------------------|------------------|----------------|--------------------------------|------------------|----------------|-----|
| Mrk 348    | 4531                           | 25               | 12             | 4529                           | 25               | 9              | 160 |
| NGC 1068   | 1009                           | 23               | 9              | 984                            | 28               | 18             | 82  |
| Mrk 1058   | 5102                           | 127              | 27             | 5089                           | 167              | 18             | 115 |
| Mrk 607    | 2777                           | 133              | 139            | 2750                           | 131              | 140            | 140 |
| NGC 1365   | 1617                           | 60               | 153            | –                              | –                | –              | 49  |
| NGC 1358   | 4083                           | 84               | 124            | –                              | –                | –              | 15  |
| NGC 1386   | 822                            | 22               | 7              | –                              | –                | –              | 25  |
| NGC 1566   | 1469                           | 33               | 30             | –                              | –                | –              | 40  |
| NGC 1667   | 4641                           | 138              | 159            | –                              | –                | –              | 165 |
| Mrk 6      | 2344                           | 172              | 167            | –                              | –                | –              | 165 |
| Mrk 79     | 6625                           | 147              | 8              | 5628                           | 171              | 36             | 130 |
| NGC 2787   | 672                            | 68               | 75             | –                              | –                | –              | 110 |
| MCG -05-23-016 | 2537 | 66             | 66             | 2549                           | 72               | 157            | 50  |
| NGC 3081   | 2412                           | 75               | 143            | –                              | –                | –              | 70  |
| NGC 3227   | 1122                           | 0                | 171            | 1041                           | 14               | 175            | 153 |
| NGC 3516   | 2608                           | 36               | 10             | 2621                           | 24               | 13             | 27  |
| NGC 3783   | 2969                           | 75               | 15             | –                              | –                | –              | 100 |
| NGC 3786   | 2682                           | 74               | 82             | 2685                           | 75               | 90             | 70  |
| NGC 3982   | 1107                           | 25               | 34             | –                              | –                | –              | 15  |
| NGC 4180   | 2042                           | 177              | 52             | –                              | –                | –              | 20  |
| NGC 4450   | 1920                           | 36               | 84             | –                              | –                | –              | 0   |
| NGC 4501   | 2238                           | 124              | 160            | –                              | –                | –              | 140 |
| NGC 4593   | 2485                           | 95               | 115            | 2489                           | 83               | 125            | 120 |
| MCG -06-30-015 | 2325 | 117             | 112            | 2323                           | 111              | 109            | 115 |
| NGC 5728   | 2772                           | 173              | 143            | 2812                           | 172              | 148            | 2   |
| NGC 5899   | 2671                           | 49               | 177            | 2672                           | 9                | 176            | 20  |
| NGC 6300   | 1111                           | 161              | 58             | 1089                           | 24               | 61             | 118 |
| NGC 6814   | 1637                           | 170              | 135            | 1667                           | 144              | 148            | 65  |
| NGC 7213   | 1859                           | 128              | 159            | –                              | –                | –              | 70  |

Photometric major axis for most galaxies is taken from the 2MASS Extended Source Catalog (XSC), with the exception of those marked with \textsuperscript{†}. For NGC 5729 the PA was taken from (Erwin 2004), and for the remaining three the PA was visually estimated from the DSS images.

5.2 Velocity fields and \textit{W}_{80} maps

Most velocity fields are dominated by a rotation component, consistent with the "S" (spiral) morphology type of the galaxies as listed in the first column of Table 2. This rotation pattern can be seen in the individual velocity maps in Appendix C (available as online supplementary material), and it orientation was determined based on the assumption of a symmetric velocity field (see section 5). But in most cases the rotation pattern is disturbed due to the presence of non-circular motions, as described below. The nature of this non-circular component has been investigated in previous studies by our group for a number of individual cases, as discussed in the appendix A, being associated to inflows along nuclear spirals and/or to outflows. In this section we point out signatures of outflows in the gas velocity fields and \textit{W}_{80} maps, using \textit{W}_{80} as an indicator of the mechanical feedback of the outflows in the host galaxy. A further analysis of the gas kinematics is deferred to a forthcoming paper where we will present modelling of the gas velocity fields and their comparison with the stellar velocity field.

Inspection of the velocity fields and \textit{W}_{80} maps show that in 5 cases – Mrk 348, NGC 1068, NGC 3227, NGC 3516 and NGC 5728 – increased \textit{W}_{80} values – reaching \textit{W}_{80} \geq 600 km s\textsuperscript{-1} surround regions of blue and redshifts to both side of the nucleus where steep velocity gradients are observed along the ionisation axis and can be interpreted as due to outflows. We interpret the increase in \textit{W}_{80} as compression of the surrounding gas by the passing outflow. There are some cases in which an increase in \textit{W}_{80} is also observed in association to blue and redshifts along the ionisation axis but which do not produce \textit{W}_{80} \geq 600 km s\textsuperscript{-1}: Mrk 1058, NGC 4501 and NGC 6814.

Increase in the values of \textit{W}_{80}, reaching \textit{W}_{80} \geq 600 km s\textsuperscript{-1}, not along but approximately perpendicularly to the ionisation axis have been found in another 5 cases: NGC 1386, NGC 2110, Mrk 6, Mrk 79 and NGC 5899. Our interpretation in these cases is a lateral expansion of the surrounding gas by an outflow or jet. The cases in which the increase of \textit{W}_{80} is observed only perpendicularly to the ionisation axis can be interpreted as due to the fact that the outflow or jet is launched at an angle to the galaxy plane, and does not have much gas to compress along its path, only at its base in the galaxy plane. In the cases of
Mrk 607 and NGC 3081, we also observe an increase in $W_{80}$ perpendicularly to the ionisation axis, but it does not reach the 600 km s$^{-1}$ threshold for its feedback to be considered as significant.

In three cases – NGC 1667, NGC 2787 and NGC 4180 – $W_{80} \geq 600$ km s$^{-1}$ is observed in a small patch close to the nucleus, bringing the total number of galaxies for which we have evaluated the feedback power of the outflows to 13 of the 30 galaxies of our sample.

In all the cases for which $W_{80} \geq 600$ km s$^{-1}$, we suggest that the increase in $W_{80}$ traces mechanical feedback from the AGN, justifying its use in the quantification of the power of the outflow. In support to this interpretation we find also a notable correspondence between regions of high $W_{80}$ and high density, which will be further discussed in section 6.

We find additional signatures of outflows with $W_{80} \leq 600$ km s$^{-1}$ in NGC 1365 and NGC 4593, bringing the total number of galaxies with signatures of outflows but with $W_{80} \leq 600$ km s$^{-1}$, to 7. Thus, considering all signatures of outflows, we find them in 21 of the 30 galaxies of our sample.
5.3 Determining the ionisation axis

The ionisation axes were determined from the flux maps of the [N\text{ii}] and [O\text{iii}] lines. In order to quantify the orientation in an objective manner, we developed a method that searches for peaks in the flux map in polar coordinates. An example of this method, applied on the galaxy NGC 1386, is shown in figure 6.

First the image is transformed to polar coordinates based on a given centre position, and bins of angle and radius. We then have, for each radius, a separate flux as a function of the angle, which are represented by the lines in figure 6. Best results were achieved by using 72 bins in angle, and a step in radii of 3 pixels (0.27 arcsec), with further smoothing by convolution with a Gaussian kernel. After that each curve was normalised with respect to its maximum value. A final step, essential to avoid artificial border effects, was repeating the curves once in each angular direction, effectively wrapping the plot, and guaranteeing that pixel at zero degrees matches the pixel at 360 degrees. Figure 7 shows the resulting curves for the [N\text{ii}] flux map of NGC 1386 shown in figure 6.

The peaks in flux for each radius are identified by selecting those points which have lower values on either side, that are at a minimum distance of 120 degrees from another peak, and that have a prominence of at least 0.3. This prominence is the difference between the height of the peak in question and the lowest point between this peak and its closest neighbour. After the direction of the peak in emission is identified for each radius, the general direction of the ionisation axis is determined by a weighted mean, where the weight is the product from the distance from the centre of the galaxy and the prominence (see above) of the peak.

This method for determining the ionisation axis has two main advantages: it is objective, although a little complicated at first, and it is not limited to a particular configuration of the emission profile. Fitting ellipses to isophotes, for instance, is challenging if the emission is one sided, or if it is dominated by a spiral structure.

6 DISCUSSION

6.1 Ionisation and kinematic axes

Fig 8 shows the correlation between the ionisation axis PA based on the emission of [N\text{ii}] vs [O\text{iii}] (see subsection 5.3). It is clear that there is a very good agreement between the two, which is to be expected, since the flux intensity of both lines is following the same ionised structure. There are only two galaxies which differ by a reasonable amount from this direct correspondence: MCG-05-23-016 and Mrk 6, and they both have almost circular emission profiles, which reduces their significance.

The direction of the ionisation axis is a tracer of the orientation of the AGN’s central engine, being perpendicular to the plane of the accretion disk and the dusty torus. Some previous studies have shown that there is no relation between the the orientation of the ionisation axis and that

\footnote{We have used the \texttt{find_peaks} function of the \textsc{scipy} package to implement the peak finding method.}
Figure 8. Comparison between the ionisation axis for the [N\text{\textsc{ii}}] and [O\text{\textsc{iii}}] lines. There is a general agreement between the two, with only two galaxies differing by more than 15 degrees. Only the 16 galaxies with spectral coverage reaching down to the [O\text{\textsc{iii}}] 5007 Å line are shown here, although we have measured the [N\text{\textsc{ii}}] ionisation axis for the whole sample.

Figure 9. Histogram of difference between the photometric major axis position angle, and the orientation of the ionisation axis. If there was an alignment between the plane of the AGN and that of the host galaxy’s disk there should be a concentration at high values of $\Delta PA$. Both distributions, either considering the [N\text{\textsc{ii}}] or [O\text{\textsc{iii}}] emission, are indistinguishable from an uniform distribution (p-value > 0.3).

Figure 10. Difference between the orientation of the photometric major axis PMA and the gas kinematic major axes [O\text{\textsc{iii}}] and [N\text{\textsc{ii}}] KMA at the central kiloparsec (Table 3) Since the PMA admits two rotation directions, the differences shown here are restricted to 90 degrees. Blue bars represent $\Delta PA_k$ for the [N\text{\textsc{ii}}] velocity field, while orange bars refer to the [O\text{\textsc{iii}}] velocity field.

of the plane of the galaxy (Schmitt et al. 2003b), although others argue for a preferable orientation of the AGN axis perpendicular to the galaxy plane, which would mean that the AGN plane would be preferably aligned with the galaxy plane (He et al. 2018). Here we use the orientation of the photometric major axis PMA (Table 3) as an indicator of the orientation of the galaxy plane. If the AGN’s plane is aligned with the disk of the host galaxy, then the ionisation axis should preferentially be found in a direction perpendicular to the PMA, otherwise there should be not preferred relative orientation between the two.

We investigate this possibility in Fig. 9, which is an histogram of the modulus of the difference between the PMA and the ionisation axis, for both [N\text{\textsc{ii}}] and [O\text{\textsc{iii}}] emission lines. The results are compatible with there being no preferential orientation of the AGN with respect to the disk of the host galaxy. A KS test comparing the measured distribution of $\Delta PA$ against a uniform distribution with the same dispersion returns p-values > 0.3, meaning that the current sample is statistically indistinguishable from random orientations for the ionisation axis relative to the galaxy plane.

The PMA is also a good proxy for the orientation of the large scale kinematics of the host galaxy (dominated by rotation in the galaxy plane), since all of our targets are disk galaxies. By comparing the orientation of the velocity fields probed by our measurements with that of the PMA we can assess the misalignment between the ionised gas kinematics within the FoV of our measurements with that of the large scale kinematics of the galaxy. In order to investigate this, we present in Figure 10 two histograms, showing the difference between the orientations of the kinematic major axes KMA of [N\text{\textsc{ii}}] and [O\text{\textsc{iii}}] velocity fields (Table 3) and that of the PMA. We note that the PMA is the same for two rotation directions, causing this analysis to be restricted to a misalignment of 90 degrees or less; if a source has $\Delta PA_k = 180$ degrees it would show as $\Delta PA_k = 0$, but we have only one such case in our sample, Mrk 607 (Freitas et al. 2018).

The analysis of Fig. 10 reveals that, for the [N\text{\textsc{ii}}] velocity field, there is a concentration towards low values of $\Delta PA_k$, meaning that for most sources the [N\text{\textsc{ii}}] velocity field is dominated by co-planar rotation with the galactic
disk. But, when considering the [O III] velocity field, the distribution of \( \Delta \) PA\(_k\) is skewed towards higher values, which we interpret as a consequence of its closer connection with the AGN outflow that is oriented at random directions relative to the galaxy plane, as discussed above.

6.2 AGN Bolometric Luminosities

In order to relate the AGN properties with its total luminosity, we have estimated the bolometric luminosities from X-Ray fluxes in the 14-195 keV band when available, and from the 2-10 keV band otherwise. Conversion between X-Ray luminosity and bolometric luminosity follows band specific correction formulae, both based on Marconi et al. (2004). For the 2-10 keV band specifically, we used equation 21 from Marconi et al. (2004).

\[
\log \left( \frac{L_{12}}{L_{2-10 \text{ keV}}} \right) = 1.54 + 0.24 L_{12} + 0.012 L_{12}^2 - 0.0015 L_{12}^3
\]

(2)

where \( L_{12} = (\log (L_{\text{AGN}}) - 12 \) and \( L_{\text{AGN}} \) is the bolometric luminosity in units of \( L_\odot \). However, for the majority of targets the 14-195 keV flux from the Swift-BAT survey was available, and the bolometric correction followed equation 5 from Ichikawa et al. (2017):

\[
L_{\text{AGN}} = 0.0378 (\log L_{14-195 \text{ keV}})^2 - 2.03 \log L_{14-195 \text{ keV}} + 61.6
\]

(3)

The bolometric luminosities obtained using the above two equations are listed in the last column of Table 4.

6.3 Gas kinematics

For the remainder of this section we adopt the hypothesis that the signature of mechanical feedback of outflows onto the surrounding medium is an increase in \( W_{50} \), and from there we calculate the associated mass-outflow rates and kinetic powers. This analysis based on general criteria differs from the one presented in section 5, where we discussed outflows considering more aspects of the velocity field.

In order to quantify the outflows, we need to identify the spaxels in which the ionised gas kinematics is not compatible with disk rotation. A spaxel is defined as being part of an outflow, or having its nebular emission dominated by outflowing gas according to the following criteria:

- It has \( W_{50}(H\alpha) > 6 \text{ Å} \) to ensure an accurate value for \( L_{H\alpha} \). Keeping in mind that, in a fraction of galaxies, the stellar spectrum has not been subtracted, this limit in \( W_{50}(H\alpha) \) means that the \( H\alpha \) emission typically has \( W_{50}(H\alpha) \geq 9 \text{ Å} \), since the \( W_{50}(H\alpha) \) associated with the absorption is expected to be close to 3 Å.

- The velocity dispersion measured by \( W_{50} \) of the [O III] or [N II] emission lines must be above a limit which excludes reasonable expectations for bound orbits in the galaxy’s potential. For this limit we chose \( W_{50} > 600 \text{ km s}^{-1} \). Although the [O III] 5007Å line is a better proxy for the gas ionised by radiation from the AGN, we decided to include also measurements using the [N II] line to avoid limiting the size of our sample to those for which such measurements could be made.

- It has at least two more neighbouring spaxels also classified as having outflows. This last criterion ensures that isolated spurious spaxels are not included in the outflow mask. Since the FWHM of the point spread function typically spans 3 to 6 spaxels, isolated detections must be false positives.

Using these simple and very general criteria, we reach the conclusion that 13 out of the 30 AGN’s in our sample display signatures of outflows in ionised gas via \( W_{50} \). These galaxies can be identified in Table 4 as those for which we show the mass outflow rates \( \dot{M} \) and outflow powers \( \dot{E} \).

6.4 Gas densities in the outflows

We have used the [S II] lines \( \lambda \lambda 6716, 6731 \text{ Å} \) to estimate the electron density at each spaxel of our sample galaxies. The actual computation followed the equations of Proxauf et al. (2014). The only galaxies for which we do not show electron density estimates are NGC 3227 and NGC 3786 due to an observational problem that precluded the use of the [S II] lines. For all spectra we adopted a fixed standard electron temperature of \( 10^4 \text{ K} \). If temperatures in the outflows were higher, this would increase the estimated densities.

Figure 11 shows the histogram of electron densities for spectra identified as having outflows (corresponding to spaxels with \( W_{50} \geq 600 \text{ km s}^{-1} \)) as compared to those without outflows. The histograms are given in units of probability density, which means that the integral of the histogram equals 1. Median values are \( 305^{+266}_{-147} \text{ cm}^{-3} \) and \( 794^{+620}_{-495} \text{ cm}^{-3} \) for the non-outflow and outflow samples respectively, where the given intervals are the distances from the median to the 16 and 84 percentiles. Spectra for which only upper or lower limits could be given, due to the saturation of the line ratio, are not included in these statistics. The number of sample points are 14604 and 2110 for non-outflows and outflows, respectively.

We performed a Kolmogorov-Smirnov (KS) test in order to ascertain the statistical significance of the difference in distributions of electron densities, arriving at a value \( D = 0.51 \) (a value of 0 indicates that both distributions are drawn from the same sample). Given the large size of this sample of spectra, we can confirm the rejection of the null hypothesis with a confidence, given by the p-value, of \( p < 0.1 \%. \) Therefore we conclude that the gas in outflow is on average denser than the rest of the narrow line region, by a factor of 1.7. This result supports that the criteria listed in section 6 are indeed selecting a physically distinct portion of the emitting gas.

This same effect can also be seen in plots comparing the electron density to the \( W_{50} \) for each spectrum, which are shown in figures 12 and 13. Only spectra satisfying the following conditions were used in these figures: i) SNR in the [S II] lines above 3; ii) no bad pixel flags compromising the accuracy of \( W_{50} \) in the [S II] or [O III] lines; iii) [S II] unaffected by strong telluric lines. Adoption of these criteria reduced the number of points to about \( 1.4 \times 10^4 \), which represent roughly ten percent of all the spectra in the sample. The two regimes identified in the histogram (Figure 11) are now seen as two clouds: one having \( W_{50} \sim 400 \text{ km s}^{-1} \) and low densities, and the other with \( W_{50} \) above \( 800 \text{ km s}^{-1} \) and higher densities.
Our interpretation of this connection between velocity dispersion and electron density is that the gas which forms the outflow is encountering the galaxy’s interstellar medium (ISM) and increasing the local density. Of course, this interpretation requires the outflow to be directed along a direction which meets the disk of the galaxy. Outflows perpendicular to the galaxy’s disk would, therefore, produce a comparatively smaller effect on the density. Another possibility could be that the outflowing gas is being spread out in the direction of the line of sight, hence the increase in $W_{80}$, when it meets regions of higher density in the ISM. Both interpretations differ in the cause attributed to the increased $W_{80}$, which is intrinsic to the outflow in the first, and a consequence of higher density clouds in the second.

6.5 Ionised gas mass

The ionised gas mass was calculated for each individual spaxel of each galaxy as:

$$M = \frac{m_p L_{\text{H}\alpha}}{n_e j_{\text{H}\alpha} (T)}$$

where $m_p$ is the proton mass, $n_e$ is the number density of electrons from the [S\text{II}] flux ratio, $L_{\text{H}\alpha}$ is the H\alpha luminosity and $j_{\text{H}\alpha}$ is the H\alpha emissivity in erg cm$^{-3}$ s$^{-1}$ for a given temperature.

Since we did not measure the temperature based on the nebular emission, we assume a standard value for the electron temperature of $T = 10^4$ K. The H\alpha luminosity was corrected only for foreground Galactic extinction based on the CCM (Cardelli et al. 1989) extinction law, using the dust maps from IRSA (Schlegel et al. 1998). A factor of $10^{0.4 A}$ was applied to the measured flux, where $A$ is the extinction in magnitudes for the SDSS r’ band. We did not correct for extinction within the galaxy due to the fact that we do not have suitable H\beta fluxes or other reddening indicators to obtain the internal attenuation. A histogram of the total ionised gas masses for our sample, obtained by summing the masses evaluated at each spaxel within the observed field of view, is shown in Fig. 14.

6.6 Mass outflow rates

In order to calculate the mass outflow rates we have used the H\alpha luminosity. However, instead of using the total flux of H\alpha emission, we used only the fraction of the flux which corresponds to velocities above 600 km s$^{-1}$ from the line centre. This ensures that even if the $W_{80}$ of H\alpha is different from that of [O\text{III}], only the emission from the outflowing gas is considered.

Mass outflow rates are given by equation 5 below. The basic assumption is that the outflow velocity $v$ we see now
Figure 14. Histogram of ionised gas mass of galaxies in the sample (within the IFU’s field of view), based on the Hα luminosity and the gas density derived from the [sii] line ratio.

is approximately the average velocity of the gas since it left the vicinity of the AGN. Therefore, the time it took for the gas to reach its current distance from the central engine is \( t = \frac{R}{v} \).

\[ \dot{M} = \frac{M}{R} \]  \hspace{1cm} (5)

where we have adopted 1/2 \( W_{80} \) as a proxy for the outflow velocity, which should be a good approximation when considering many galaxies, and therefore, many different projections for the outflow. The resulting mass outflow rate values for each galaxy, as derived from the kinematics of both the [O iii] and [N ii] lines, are given in table 4.

By far the most uncertain term in 5 is the distance \( R \). Even before any projection effects are taken into account, one first has to consider where the gas is being accelerated, either at the vicinity of the AGN or in situ (i.e. Kraemer et al. 2020, and references therein). In this work we adopt a model of outflow in the form of an expanding spherical shell, which we assume to be accelerated at the nucleus. We define the outflow travel distance \( R \) as the largest radius, in the plane of the sky, for which we observe \( W_{80} \gg 600 \text{ km s}^{-1} \). This is, of course, a lower limit for the travel distance in the likely case that the outflows are not spherically symmetric. As a result, our estimates of mass outflow rates should be considered as upper limits.

In figure 15 we show the relation between the mass outflow rates \( \dot{M} \) and the AGN bolometric luminosity \( L_{\text{AGN}} \) for the 13 galaxies of our sample with outflows as traced by \( W_{80} \gg 600 \text{ km s}^{-1} \) together with previous results from the literature. Spectral types Sy 1 and Sy 2 and LINERs are represented by different symbols in the figure, although we are not implying any distinction in the outflow mechanism. In this plot we see that the values obtained for our galaxies follow the trend of the sub-linear correlation with \( L_{\text{AGN}} \) from Fiore et al. (2017) – the blue dashed line in the Figure. The scatter is nevertheless large, with four points two orders of magnitude above the mean relation, one on the relation and the rest of the sample 1–2 orders of magnitude below the relation. Most of the points below the relation occupy the same space as those from Baron & Netzer (2019). We have also added points compiled by Shimizu et al. (2019) for reference. Some of our galaxies are also present in these references, therefore the same galaxy might be represented by more than one point.

When comparing the galaxies with and without outflows a small trend is also observed, although the luminosities are consistent within uncertainties. For the 13 galaxies with outflows the average AGN luminosity is \( \log L_{\text{AGN}} = 43.83 \pm 0.83 \), while for galaxies lacking outflows the average value is \( \log L_{\text{AGN}} = 42.94 \pm 1.54 \).

### 6.7 Outflow power

Having the mass outflow rate, estimating the outflow power is relatively straightforward. We consider only the mechanical power of the outflow, disregarding eventual heating and expansion of the outflowing gas. The total kinetic power of the outflow is given by:

\[ P = \frac{1}{2} \dot{M} v^2 \]  \hspace{1cm} (6)

where \( v \) is the outflow velocity, taken to be 1/2 \( W_{80} \) for \( W_{80} \) higher than 600 km s\(^{-1}\). The calculated values are shown in the 4\(^{th}\) and 7\(^{th}\) columns of Table 4, and range between \( 10^{36.2} \text{ erg s}^{-1} \) for the LINER in NGC 2787 to \( 10^{33.3} \text{ erg s}^{-1} \) for the Sy 1 in Mrk 6, with a median value of \( \log [E/(\text{erg s}^{-1})] = 38.5^{+1.8}_{-0.8} \) when considering [N ii] based \( W_{80} \). Similar results are found for [O iii] based estimates, with a median outflow power of \( \log [E/(\text{erg s}^{-1})] = 38.4^{+2.2}_{-0.8} \).

Figure 16 shows the relation between the outflow kinetic...
Table 4. Outflow rate, power and bolometric luminosity – Columns are: (1) name of the galaxy; (2 and 5) distance in the plane of the sky from the galactic centre to the last spaxel identified as outflow dominated; (3 and 6) mass outflow rates; (4 and 7) outflow kinetic power; (8) outflow position angle; (9) AGN bolometric luminosity.

| Galaxy   | $R_{\text{max}}$ [N ii] pc | log $\dot{M}$ [N ii] $\odot$ yr$^{-1}$ | log $\dot{E}$ [N ii] erg s$^{-1}$ | $R_{\text{max}}$ [O iii] pc | log $\dot{M}$ [O iii] $\odot$ yr$^{-1}$ | log $\dot{E}$ [O iii] erg s$^{-1}$ | Outflow PA$^\circ$ | log $L_{\text{AGN}}$ erg s$^{-1}$ |
|----------|-----------------------------|-----------------------------------------|----------------------------------|-------------------------------|-----------------------------------------|----------------------------------|------------------------|-------------------------------|
| Mrk 348  | 158                         | -2.64                                  | 38.15                            | 171                           | 0.32                                    | 41.58                            | 19                     | 44.08                          |
| NGC 1068 | 171                         | 0.30                                   | 41.38                            |                               |                                         |                                  | 30                     | 42.85                          |
| Mrk 1058 | 44                          |                                         |                                  |                               |                                         |                                  |                        |                                |
| Mrk 607$^\dagger$ | 45                  | 43.45                                  |                                  |                               |                                         |                                  |                        |                                |
| NGC 1365 | 118                         | 43.48                                  |                                  |                               |                                         |                                  |                        |                                |
| NGC 1358 | 120                         | 42.05                                  |                                  |                               |                                         |                                  |                        |                                |
| NGC 1386$^\dagger$ | 110        | 40.89                                  |                                  |                               |                                         |                                  |                        |                                |
| NGC 1566 | 164                         | 41.14                                  |                                  |                               |                                         |                                  |                        |                                |
| NGC 1667 | 54                          | 45.11                                  |                                  |                               |                                         |                                  |                        |                                |
| Mrk 6$^\dagger$ | 1058            | 45.19                                  |                                  |                               |                                         |                                  |                        |                                |
| NGC 2787 | 158                         | 41.56                                  |                                  |                               |                                         |                                  |                        |                                |
| MCG-05-23-016 | 44.99              |                                         |                                  |                               |                                         |                                  |                        |                                |
| NGC 3081 | 0                           |                                         |                                  |                               |                                         |                                  |                        |                                |
| NGC 3227 | 27                          | 43.91                                  |                                  |                               |                                         |                                  |                        |                                |
| NGC 3516 | 15                          | 44.58                                  |                                  |                               |                                         |                                  |                        |                                |
| NGC 3783 | 44.81                      |                                         |                                  |                               |                                         |                                  |                        |                                |
| NGC 3786 | 43.70                      |                                         |                                  |                               |                                         |                                  |                        |                                |
| NGC 3982 | 40.86                      |                                         |                                  |                               |                                         |                                  |                        |                                |
| NGC 4180 | 45.57                      |                                         |                                  |                               |                                         |                                  |                        |                                |
| NGC 4450 | 41.04                      |                                         |                                  |                               |                                         |                                  |                        |                                |
| NGC 4591 | 40.57                      |                                         |                                  |                               |                                         |                                  |                        |                                |
| NGC 4593 | 44.01                      |                                         |                                  |                               |                                         |                                  |                        |                                |
| MCG-06-30-015 | 44.20              |                                         |                                  |                               |                                         |                                  |                        |                                |
| NGC 5728 | 135                         | 44.02                                  |                                  |                               |                                         |                                  |                        |                                |
| NGC 5899$^\dagger$ | 151           | 43.72                                  |                                  |                               |                                         |                                  |                        |                                |
| NGC 6300 | 26                          | 43.43                                  |                                  |                               |                                         |                                  |                        |                                |
| NGC 6814 | 151                         | 43.72                                  |                                  |                               |                                         |                                  |                        |                                |
| NGC 7213 | 43.43                      |                                         |                                  |                               |                                         |                                  |                        |                                |

$^\dagger$ Galaxies with equatorial outflow.

7 CONCLUSIONS

We present an analysis of GMOS-IFU optical datacubes of the inner kpc of 30 nearby AGN (mostly at $z \leq 0.01$) that our research group AGNIFS has collected over the years, and have measured the gas excitation and kinematics via the fit of Gauss-Hermite polynomials to the emission lines. We have obtained maps of the gas emission-line flux distributions, line-ratios and kinematics with spatial resolutions in the range 50–300 pc and velocity resolution of $\approx 50$ km s$^{-1}$ and used the parameter $W_{80}$ as an indicator of outflows. Twenty one of the 30 galaxies of our sample are Swift/BAT AGN sources. We determined the orientation of the ionisation axis by finding the direction of the peak fluxes in the polar flux distributions of [N ii] and [O iii]. We fitted the [N ii] and [O iii] velocity fields with a simple symmetric model to measure the gaseous systemic velocities, the P.A. of the corresponding kinematic major axes, and to reveal the presence of outflows.

The main conclusions we have reached on the basis of the measurements outlined above are:

- Gas excitation and ionisation axis: Emission line ratios characteristic of AGN excitation are observed over most of the FoV and the gas emission clearly extends beyond the
of them are oriented along the ionisation axis and associated with an increase in the \( W_{80} \). In 7 sources, increased \( W_{80} \) values occur in a band crossing the nucleus perpendicularly to the ionisation axis which we attribute to the passage of an outflow or radio jet pushing the ambient gas sideways. Of the 21 sources with outflows, only 13 show \( W_{80} \geq 600\ \text{km\ s}^{-1} \); mass outflow rates and powers are only calculated for the latter;

- Impact of outflows via \( W_{80} \): We have employed the \( W_{80} \) index as an indicator of outflows, using a lower limit of 600 km s\(^{-1}\) to isolate regions dominated by outflows (as lower profile widths can be associated to rotation). We find such signature in 13 of the 30 AGNs of our sample. Seven additional galaxies show other signatures of outflows, although presenting \( W_{80} < 600\ \text{km\ s}^{-1} \); we attribute these low values to the fact that such outflows have a low impact on the surrounding gas;

- Gas densities \( n_e \) in the outflows: We found that the gas densities – determined via the [S\( \text{ii} \)] line ratio – tend to be higher in the regions with outflows (\( W_{80} \geq 600\ \text{km\ s}^{-1} \)) than in those without, with median values of of \( n_e \approx 800\ \text{cm}^{-3} \) and \( n_e \approx 300\ \text{cm}^{-3} \), respectively;

- Ionised gas mass within the inner kpc: Total ionised gas masses within the \( \approx \) inner kiloparsec are in the range \( 10^{4.5} - 10^8\ \text{M}_\odot \);

- Mass outflow rate \( \dot{M} \): Using \( W_{80} \) as a proxy for the outflow gas velocity \( v = 1/2 \dot{W}_{80} \) and a distance of the outflow corresponding to the largest observed radial distance from the nucleus at which \( W_{80} \geq 600\ \text{km\ s}^{-1} \), we obtain mass outflow rates in the range \( \log [ \dot{M} / (\text{M}_\odot \text{ yr}^{-1})] = -3.91 \text{ to } 2.38 \), with a median value of \( \log [ \dot{M} / (\text{M}_\odot \text{ yr}^{-1})] = -2.1_{-1.6}^{+1.6} \), where the upper and lower limits represent the 16 and 84 percentiles.

- Outflow power \( \dot{E} \): Outflow powers are in the range \( \sim 10^{42}\ \text{erg\ s}^{-1} \) to \( \sim 10^{43}\ \text{erg\ s}^{-1} \). When compared to the AGN bolometric luminosities \( L_{\text{AGN}} \), log(\( \dot{E} \))\( \geq 0.01 L_{\text{AGN}} \) only for 2 sources, for two others \( 0.001 \geq \log(\dot{E})/L_{\text{AGN}} \geq 0.01 \), while for the remainder 10 galaxies, the powers are lower than 0.001 \( L_{\text{AGN}} \).

- Relation \( \dot{M} \) vs. \( L_{\text{AGN}} \): The mass outflow rate shows some correlation with \( L_{\text{AGN}} \), with a large scatter; when compared to the previous results from the literature (e.g. Fiore et al. 2017), they seem to approximately follow the same relation, on average, with three points above, one on the relation and most of them below the relation;

- Relation \( \dot{E} \) vs. \( L_{\text{AGN}} \): There is also some correlation between the outflow powers and \( L_{\text{AGN}} \), also with a large scatter; when added to the previous relation of Fiore et al. (2017), the 4 most powerful outflows in our sample follow the trend of the being in the range \( 0.001 L_{\text{AGN}} \geq \log(\dot{E}) \geq 0.1 L_{\text{AGN}} \), while the outflows in the remaining galaxies of our sample populate a region well below the previous relation.

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DATA AVAILABILITY

The data underlying this article will be shared on reasonable request to the corresponding author. The following additional information and figures are available as online supplementary material: comments on individual galaxies (Appendix A); acquisition images with the overlaid GMOS field-of-view and sample spectrum (Appendix B); data plots for all galaxies (Appendix C); results of Gauss-Hermite higher order moments (Appendix D); WHAN diagnostic diagrams (Appendix E).

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APPENDIX A: COMMENTS ON INDIVIDUAL GALAXIES

Mrk 348 (Fig. C1): This Seyfert 2 galaxy shows the SER (see section 5 for a definition) more extended along NE-SW, at an angle of ≈ 40° with the PMA. We identify this direction as that of the ionisation axis of the AGN, along which the gas velocity map shows two compact regions (diameters of about 200 pc) at opposite sides of the nucleus, one blueshifted by ≈ −100 km s$^{-1}$ at 1.4 arcsec (420 pc) to the NE and the other redshifted to the SW (with similar velocity and distance from the nucleus). These properties can be interpreted as due to outflows from the nucleus. These outflows are associated to an increase in the $W_{80}$ values, mostly to the North, suggesting an interaction between the outflow and the local ISM (even though $W_{80}$ is lower than the 600 km s$^{-1}$ threshold we have adopted for outflows over the whole FoV). The electronic density map shows an increase in the gas, in SW, in the direction of the compact redshifted region. The data for this galaxy has been previously analysed by Freitas et al. (2018).

NGC 1068 (Fig. C2): This well studied Sy 2 galaxy shows the peak of gas emission displaced by ≈ 0.5 (30 pc) towards the NE from the centre, with the SER extending along this direction, that makes an angle of ≈ 50° with the PMA. Along this direction – that can be identified with the AGN ionisation axis – blueshifts are observed to the NE and redshifts to the SW reaching ≈ 800 km s$^{-1}$ in [O iii] at ≈ 2.7′ from the nucleus and somewhat lower values (≈ 600 km s$^{-1}$) in the [N ii] lines. Beyond the high blueshifts, redshifts are observed to the NE, evidencing the presence of more than one kinematic component and that the blue and redshifts are due to nuclear outflows. $W_{80}$ is enhanced to values as high as 2500 km s$^{-1}$ surrounding the regions with the highest velocities.

Mrk 1058 (Fig. C3): The largest extent of the SER of this Seyfert 2 galaxy is observed towards the SW, that can be identified with the orientation of the ionisation axis. This direction is almost perpendicular to the PMA. Excess blueshifts are observed in the gas relative to the symmetric [N ii] velocity field everywhere, as previously shown by Freitas et al. (2018). The blueshifts are more conspicuous in the [O iii] velocity field along the ionisation axis and are associated with an increase in the [N ii] $W_{80}$, suggesting the presence of an outflow impacting the ISM there, even though $W_{80}$ ≤ 600 km s$^{-1}$ everywhere.

Mrk 607 (Fig. C4): The SER in this Seyfert 2 galaxy is most extended to the NW along the PMA which also coincides with the kinematic major axis (KMA). Freitas et al. (2018) have shown that the gas in this galaxy counter-rotates relative to the stars, suggesting an external origin. An increase in $W_{80}$ is observed in a ∼ 200 pc wide band crossing the nucleus perpendicularly to the PMA. This increase is approximately co-spatial with the increase in the gas density and in the gas velocity dispersion as previously reported by Freitas et al. (2018) and tentatively attributed to an equatorial outflow related to the AGN and its radio emission, as the ionisation axis seems to be along the PMA. Schönell et al. (2019) reach similar conclusions, reporting an equatorial outflow of molecular gas, traced by the H$_2$ emission.

NGC 1365 (Fig. C5): The FoV of our observations of this nearby Sy 1 galaxy covers only ≈ 300 × 400 pc at the galaxy, the SER being extended beyond the FoV. An increase in the electronic density is observed towards the SE, in agreement with the measurements by Lena et al. (2016) who have also obtained GMOS-IFU spectroscopy of this galaxy over a somewhat larger FoV. Over an even larger FoV, a cone-shaped structure has been observed extending by 1.5 kpc to the SE in [O iii] by Storchi-Bergmann & Bonatto (1991) and associated outflows have been observed in previous studies (Sharp & Bland-Hawthorn 2010).

NGC 1358 (Fig. C6): This Sy 2 galaxy shows emission that peaks at the nucleus, with the SER, observed in [N ii], showing an S-shape structure, being most extended approximately perpendicularly to the PMA. The kinematics show a distorted rotation pattern with the KMA approximately along the S-shape structure, almost perpendicular to the PMA. Two emission blobs at 2 arcsec (∼ 500 pc) from the nucleus at the end of the S are associated with an increase in $W_{80}$ and can be attributed to outflows from the nucleus (as previously discussed in Schnorr-Müller et al. (2017b)).

NGC 1386 (Fig. C7): This Sy 2 galaxy shows emission peaking at the nucleus and an ionisation axis making a small angle (≈ 20°) with the PMA, the latter of which is in approximate agreement with the KMA. Lena et al. (2015) pointed out the presence of a compact outflow along the ionisation axis that is not resolved by our observations. The kinematics show distorted rotation and the most conspicuous feature is an increase in $W_{80}$ perpendicularly to the ionisation axis, attributed to gas in equatorial rotation and outflow (as previously discussed in Lena et al. (2015)). This increase in $W_{80}$ is associated with an increase in the gas density. Based on coronal lines seen in the near infrared spectrum of this galaxy, Rodríguez-Ardila et al. (2017) estimate a mass outflow rate of 11 M$_{\odot}$ yr$^{-1}$.

NGC 1566 (Fig. C8): This Sy 1 galaxy shows emission peaking at the nucleus and a very compact SER; at lower flux levels it is more extended along the PMA that seems to coincide with the KMA. A large HII region is observed at ≈ 2 arcsec (∼ 60 pc) SW of the nucleus. A distorted rotation pattern seems to be due to motions along nuclear spiral arms that could be associated to inflows seen in cold molecular gas kinematics in observations with the Atacama Large Millimetric Array ALMA (Combes et al. 2014). Combining data from ALMA and GMOS Slater et al. (2019) argue for the presence of molecular and ionised gas outflows in the inner kiloparsec of this galaxy.

NGC 1667 (Fig. C9): This Sy 2 galaxy shows the SER slightly more extended towards the SW. The kinematics show a distorted rotation pattern with an KMA apparently tilted by ≈ 30° relative to the PMA. This distortion has been attributed to inflows along nuclear spiral arms (Schnorr-Müller et al. 2017b). [N ii] $W_{80}$ shows the highest values in an arc structure just to the north of the nucleus. As $W_{80}$ >600 km s$^{-1}$, we have considered the presence of an outflow there.

NGC 2110 (Fig. C10): This Sy 2 galaxy shows the SER more elongated towards the N-NW, that can be identified with the orientation of the ionisation axis, which is approximately also the orientation of the PMA and KMA. The kinematics shows a distorted rotation pattern – previously analysed by Schnorr-Müller et al. (2014a) with optical data and Diniz et al. (2015) in the near-IR – with enhanced $W_{80}$ along a “band” crossing the nucleus almost perpendicular to the
ionisation axis, attributed to an equatorial outflow as in the case of NGC 1386. The increased \( W_{\text{SO}} \) seems to be associated to an increase also in the gas density.

**Mrk 6 (Fig. C11):** This Seyfert 1 galaxy shows the SER more extended along the N-S direction and a distorted rotation pattern in the emitting gas, as previously pointed out by Freitas et al. (2018). The rotation component seems to have a KMA following the orientation of the PMA, more clearly seen in [N\text{II}]. In [O\text{III}], the increase in the blueshifts to the North and redshifts to the South, indicate the presence of an *outflow* making an angle of \( \approx 50^\circ \) with the PMA. This N-S outflow is approximately co-spatial with a radio structure seen in a 3.6 cm image (Freitas et al. 2018). High values of \( W_{\text{SO}} \) are observed over most of the FoV, and being highest in two regions aligned almost perpendicularly to the radio-structure and outflow, as in NGC 2110 and NGC 1386, probably due again to an *equatorial outflow* produced by the passage of the radio jet.

**Mrk 79 (Fig. C12):** This Sy 1 galaxy shows the SER elongated towards the S-SW, at an angle of 55° relative to the PMA, extending beyond the border of the FoV. This direction (P.A. \( \approx 190^\circ \)) can be identified with the ionisation axis of the AGN, as evidenced in the narrow-band image of Schmitt et al. (2003a), which is also the orientation of the jet-like 3.6 cm radio continuum image (Schmitt et al. 2001). In [O\text{III}], we find blueshifts to the South that we attribute to an *outflow* along the ionisation axis, while in [N\text{II}] lower velocity blueshifts are also observed there. Blueshifts are also observed to the NW, but their origin is not clear, seeming to be a counterpart to a redshifted region observed to the SE in the [N\text{II}] emission. \( W_{\text{SO}} \) is enhanced approximately perpendicularly to the ionisation axis, this can again be attributed to an *equatorial outflow* due to the passage of the radio jet. The gaseous kinematics of this galaxy has been previously studied in the near-IR by Riffel et al. (2013), who also found strongest gas emission to the south, and similar kinematics to ours in the Pa\(\beta\) and [Fe\text{II}] emission lines. Freitas et al. (2018) has analysed these data in a previous study but the SER elongation was mistakenly identified as being oriented towards the North in that paper.

**NGC 2787 (Fig. C13):** This galaxy has a LINER nucleus, very compact SER (\( \approx 40 \) pc) that peaks at the nucleus and extended emission that shows a rotation pattern with KMA tilted by \( \approx 31^\circ \) relative to the PMA. Its kinematics and excitation have been investigated in Brum et al. (2017). The [N\text{II}] \( W_{\text{SO}} \) is high at the nucleus and its distribution is elongated to the NW approximately along the kinematic minor axis, which could be due to an *outflow* along this direction.

**MCG-5-23-16 (Fig. C14):** This Seyfert 1 galaxy shows the peak of the [O\text{III}] emission off-centred by \( 0''5 \) to the E of the nucleus and the SER in [O\text{III}] being most extended approximately along the PMA, that seems to coincide with the KMA. The [N\text{II}] kinematics is dominated by rotation, with a steeper gradient than that of the [O\text{III}] kinematics, suggesting the presence of another, non-rotating component in the latter.

**NGC 3081 (Fig. C15):** This Sy 2 galaxy shows gas emission peaking at the nucleus, a SER elongated to the N-NW, approximately perpendicularly to the PMA. A nuclear bar is observed along the PMA, whose orientation is in approximate agreement with that of the KMA. A distorted rotation pattern, observed in [N\text{II}] has been associated to inflows along the bar, combined with a compact nuclear *outflow* almost perpendicular to the bar – as previously discussed in Schnorr-Müller et al. (2016). The outflow is approximately oriented along the SER, and is associated with an increase in the gas density. An increase in \( W_{\text{SO}} \) is observed surrounding the SER, probably due again to an *equatorial outflow*, or lateral displacement of the ambient gas by the outflow. Both outflows lead to \( W_{\text{SO}} \) below the 600 km s\(^{-1}\) threshold.

**NGC 3227 (Fig. C16):** The SER in this Sy 1 galaxy is very compact, but at fainter levels of gas emission is most extended towards the NE, making an angle of \( \approx 54^\circ \) with the PMA. The highest blueshifts – seeming to extend beyond our FoV are also observed in this direction. \( W_{\text{SO}} \) increases to values of the order of 1000 km s\(^{-1}\) towards the NE (P.A. \( \approx 27^\circ \)), where blueshifts are observed and can be attributed to an *outflow*, which is also supported by [Fe\text{II}] emission in the near-IR (Schönell et al. 2019). The velocity fields are distorted, dominated by blueshifts in the case of [O\text{III}] and showing also a rotation component in the [N\text{II}] kinematics, with a KMA approximately along the PMA.

**NGC 3516 (Fig. C17):** In this Sy 1 galaxy, the SER in [N\text{II}] is elongated to the N-NE border of FoV at 3''5 (\( \approx 1 \) kpc) from the nucleus, similarly observed also in [O\text{III}] but at lower flux levels. This orientation is approximately that of the PMA (also similar to that of the KMA). The kinematics suggest again a distorted rotation pattern, with the highest blueshifts (\( \approx 300 \) km s\(^{-1}\)) being observed closer to the nucleus – at \( \approx 2\) arcsec\(370\) pc N-NE, than the highest redshifts at \( \approx 1 \) kpc to the S-SW. The highest redshifts seem to occur beyond the limits of the FoV and are probably due to rotation. The region with the highest blueshifts is surrounded by very high \( W_{\text{SO}} \) values (\( \approx 1000 \) km s\(^{-1}\) and gas densities, which suggests that these blueshifts are due to an *outflow* that is pushing the surrounding gas.

**NGC 3783 (Fig. C18):** This Sy 1 galaxy shows a round SER, with a velocity field showing a low amplitude (\( \lesssim 40 \) km s\(^{-1}\)) distorted rotation with a KMA apparently tilted by \( \approx 45^\circ \) relative to the PMA. There is some elongation to the East in the [N\text{II}] gas emission flux, \( W_{\text{SO}} \) and gas density distributions following the PMA.

**NGC 3786 (Fig. C19):** This Sy 2 galaxy shows a compact SER with the gas velocity fields showing a rotation pattern with a KMA approximately along the FoV. The highest \( W_{\text{SO}} \) values are observed in an elongated structure reaching \( \approx 1''4 \) (\( \approx 300 \) pc) from the nucleus to the SE with some correspondence in the gas density map, although no signature of outflows is seen in the velocity fields.

**NGC 3982 (Fig. C20):** The [N\text{II}] SER in this Sy 2 galaxy is round and compact, reaching \( \approx 100 \) pc from the nucleus, where the highest \( W_{\text{SO}} \) and gas densities are observed. Brum et al. (2017) has studied the gas kinematics and excitation of this galaxy showing deviations from pure rotation associated with nuclear spiral structure.

**NGC 4180 (Fig. C21):** In this Sy 2 galaxy, the gas emission peaks \( \approx 0''2 \) (40 pc) E of the nucleus and the SER is more extended approximately along the PMA. The gas kinematics shows again a distorted rotation pattern with a KMA apparently tilted relative to the PMA. \( W_{\text{SO}} \) is largest just to the West of the nucleus, where it reaches \( \geq 600 \) km s\(^{-1}\) that we attribute to an *outflow* whose orientation is not clear in the the kinematic maps.

**NGC 4450 (Fig. C22):** This galaxy has a nucleus classified as
LINER 1. The long FoV reaches HII regions 5′′ from nucleus. The gas kinematics shows again a distorted rotation pattern whose KMA seems to approximately coincide with the PMA. A blueshifted knot of gas emission at \(\approx 175\) (100 pc) E of the nucleus coincides with an increase in the velocity dispersion that suggests it is gas in outflow, as previously discussed in

\cite{Brum2017}, but with \(W_{80}\) below the 600 km s\(^{-1}\) threshold.

**NGC 6501 (Fig. C23):** This Sy 2 galaxy has the [N\(\text{ii}\)] SER extended along the PMA. The kinematics shows a distorted rotation pattern with a KMA with similar orientation to that of the PMA. The distortion along the minor axis seems to be associated with an increase in \(W_{80}\) that suggests a small outflow along the minor axis, in particular to the SW, as seen also in the previous study by \cite{Brum2017}. The \(W_{80}\) is nevertheless below the 600 km s\(^{-1}\) threshold.

**NGC 6503 (Fig. C24):** This Sy 1 galaxy has the [O\(\text{iii}\)] SER most extended along the PMA, with the peak emission displaced by \(\approx 0\′\prime.3\) (40 pc) to the NE of the nucleus. The gas kinematics show a rotation pattern with a tilted KMA relative to the PMA by \(\approx 30°\). The highest \(W_{80}\) and gas densities are observed to the E-SE, what could indicate the presence of an outflow there. This seems not be supported by the velocity fields even though the [O\(\text{iii}\)] one is shallower than that in [N\(\text{ii}\)] suggesting the presence of another kinematic component in [O\(\text{iii}\)].

**MCG-6-30-15 (Fig. C25):** This is a Sy 1.2 galaxy close to edge-on, with emission peaking at the nucleus, SER most extended along the PMA, that again coincides with the KMA. Both [N\(\text{ii}\)] and [O\(\text{iii}\)] kinematics are dominated by rotation (although again showing distortions) with \(W_{80}[\text{N}\text{ii}]\) and gas density showing a small increase at the nucleus.

**NGC 5728 (Fig. C26):** This Sy 2 galaxy has elongated [N\(\text{ii}\)] and [O\(\text{iii}\)] SER’s reaching the borders of the FoV to the NW of the nucleus, making an angle of \(\approx 45°\) with the PMA that is along N-S. The peak emission is displaced by \(\approx 0\′\prime.5\) (60 pc) to the NW of the nucleus, where high redshifts (up to 350 km s\(^{-1}\)) are observed. Another peak of emission is observed further to the NW at \(\approx 3\) arcsec (400 pc) from the nucleus, where the highest blueshifts (up to \(-300\) km s\(^{-1}\)) are observed. There is a steep velocity gradient between these two regions, that is co-spatial with a region of very high values of \(W_{80}\). A recent study of this galaxy by \cite{Shimizu2019} has confirmed the presence of a bipolar outflow associated with the above two regions. Enhanced \(W_{80}\) is observed perpendicularly to the ionization and outflow axis.

**NGC 5899 (Fig. C27):** This Sy 2 galaxy shows the SER elongated in the direction N-S, tilted by \(\approx 20°\) relative to the PMA. A hint of a rotation pattern with the KMA similar to the PMA is observed towards the borders of the FoV, but opposite blueshifts and redshifts are observed internal to these regions (within the inner \(\approx 200\) pc radius) due to a compact outflow, with blueshifts to the south and redshifts to the north, in agreement with near-IR studies of the same galaxy \cite{Schonell2019}. Farther out, blueshifts and redshifts are also observed perpendicularly to the major axis, where enhanced \(W_{80}\) is observed.

**NGC 6300 (Fig. C28):** This Sy 2 shows the [N\(\text{ii}\)] and [O\(\text{iii}\)] SER more extended to the NE, approximately perpendicularly to the PMA, where blueshifts are observed in both emission lines. Blueshifts are observed also at the nucleus, while to the SW, both [N\(\text{ii}\)] and [O\(\text{iii}\)] show redshifts. The highest values of \(W_{80}\) and gas density are observed to the SW. As these structures are observed perpendicularly to the PMA, we interpret them as due to outflows, although the \(W_{80}\) value remain below the 600 km s\(^{-1}\) threshold.
APPENDIX B: ACQUISITION AND SPECTRUM
Figure B1. Acquisition images and central spectrum for each galaxy in the sample. All images are in the GMOS R filter, which is very similar to the SDSS r’ filter, and all colour maps are in logarithmic scale. The green dashed rectangle represents the limits of the IFU field of view.
Figure B2. Continuation of Figure B1.
Figure B3. Continuation of Figure B1.
Figure B4. Continuation of Figure B1.
APPENDIX C: GALAXY BY GALAXY DATA
Figure C1. Emission line fitting results for the galaxy Mrk 348. The first line of panels show the logarithm of the flux, in units of $10^{-15}$ erg s$^{-1}$ cm$^{-2}$, the radial velocity and the $W_{80}$ index of the [O III] 5007Å line; the middle line shows the same quantities for the [N II] 6583Å line; and finally the line ratios [N II] 6583Å / Hα and [O III] 5007Å / Hβ, and the logarithm of the electron density, in units of cm$^{-3}$ are shown in the bottom line. red dashed line: photometric major axis; green dashed line: ionisation axis; purple dashed line: direction of the $W_{80}$ enhanced region; blue solid line: kinematic major axis based on [N II] emission, except for the [O III] velocity field panel; blue dashed circle: maximum radius of the outflow, based on the $W_{80}$ threshold.
Figure C2. Continuation of figure C1.
Figure C3. Continuation of figure C1.
Figure C4. Continuation of figure C1.
Figure C5. Continuation of figure C1.
Figure C6. Continuation of figure C1.
NGC 1386

Figure C7. Continuation of figure C1.
Figure C8. Continuation of figure C1.
Figure C9. Continuation of figure C1.
Figure C10. Continuation of figure C1.
Figure C11. Continuation of figure C1.
Figure C12. Continuation of figure C1.
Figure C13. Continuation of figure C1.
Figure C14. Continuation of figure C1.
Figure C15. Continuation of figure C1.
Figure C16. Continuation of figure C1.
Figure C17. Continuation of figure C1.
Figure C18. Continuation of figure C1.
Figure C19. Continuation of figure C1.
AGNIFS survey of local AGN

Figure C20. Continuation of figure C1.
Figure C21. Continuation of figure C1.
Figure C22. Continuation of figure C1.
Figure C23. Continuation of figure C1.
Figure C24. Continuation of figure C1.
Figure C25. Continuation of figure C1.
AGNIFS survey of local AGN

Figure C26. Continuation of figure C1.
Figure C27. Continuation of figure C1.
Figure C28. Continuation of figure C1.
Figure C20. Continuation of figure C1.
Figure C30. Continuation of figure C1.
APPENDIX D: GAUSS-HERMITE HIGHER ORDER MOMENTS
Figure D1. Summary of results for Mrk 348. The bar in the lower left of each of the panels represents a projected proper distance of 100 pc. The colour coding is in units of km s$^{-1}$ for the velocity and velocity dispersion. The $h_3$ and $h_4$ coefficients of the Gauss-Hermite polynomials are dimensionless quantities, and the limits of the colour scale reflect the actual bounds used in the fitting process. The systemic velocity of the galaxy, inferred from the stellar velocity field, has been subtracted from the radial velocity of the emission lines.

Figure D2. Same as Figure D1, but for NGC 1068.
Mrk1058

Figure D3. Same as Figure D2, but for Mrk 1058

Mrk607

Figure D4. Same as Figure D2, but for Mrk 607
NGC 1358

![Figure D5. Same as Figure D2, but for Mrk 607](image1)

NGC 1386

![Figure D6. Same as Figure D2, but for Mrk 607](image2)

NGC 1566

![Figure D7. Same as Figure D2, but for NGC 1566](image3)
NGC 1667

Figure D8. Same as Figure D2, but for NGC 1667

NGC 2110

Figure D9. Same as Figure D2, but for NGC 2110
Figure D10. Same as Figure D2, but for Mrk 6

Figure D11. Same as Figure D2, but for Mrk 79
NGC 2787

Figure D12. Same as Figure D2, but for NGC 2787

MCG -05-23-016

Figure D13. Same as Figure D2, but for MCG -05-23-016
NGC 3081

Figure D14. Same as Figure D2, but for Mrk 3081

NGC 3516

Figure D15. Same as Figure D2, but for NGC 3516
Figure D16. Same as Figure D2, but for NGC 3786

Figure D17. Same as Figure D2, but for NGC 3982
NGC 4180

![Figure D18. Same as Figure D2, but for NGC 4180](image)

NGC 4450

![Figure D19. Same as Figure D2, but for NGC 4450](image)

NGC 4501

![Figure D20. Same as Figure D2, but for NGC 4501](image)
Figure D21. Same as Figure D2, but for NGC 5728

Figure D22. Same as Figure D2, but for NGC 5899
Figure D23. Same as Figure D2, but for NGC 6300.
APPENDIX E: WHAN DIAGRAMS
Figure E1. WHAN diagrams for all the galaxies in the sample. The defining lines for each category are based on Cid Fernandes et al. (2010). Colors represent the distance from the nucleus, increasing from blue to orange.
Figure E2. Continuation of Figure E1.
Figure E3. Continuation of Figure E1.
Figure E4. Continuation of Figure E1.