XII Congresso Nazionale sui Nuclei Galattici Attivi

# An X-ray/SDSS sample: OBSERVATIONAL CHARACTERIZATION OF THE OUTFLOWING GAS

a Multi-Messenger perspective 27/09/16

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AGN12 -

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Monday, October 10, 2016

#### FEEDBACK - GAS FLOWS DBACK - G **H ++H**





the deeper exposure and lower background, enables the detec-

tion also in the hard band (with ∠10 net counts in the 2−10 net counts in the 2−10 net counts in the 2−10 keV<br>Distribution also in the 2−10 keV counts band). Despite the limited spectral quality, the shape of the hard

**Q**

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**E,'\$F=1%:&G#1\$F+HIJ**

The great masks and stated wings in the great masks and the great current current current current current current  $n_1$  is the broadened as the broadened asymmetric component, while  $\sigma$ molecular foatures  $\text{HIOICUIdI}$  **Ed**  $H = \frac{1}{2}$  (and  $\frac{1}{2}$   $\frac{$  $\overline{\phantom{1}}$  $\mathbf{1}$ **IP HI** molecular features broad (and shifted) wings in ionized, atomic and

All nearby CT AGN show a strong (*EW* <sup>&</sup>gt;<sup>∼</sup> 1 keV) emission

line at the rest frame energy of the Fe Kα line at 6.4 keV. This feature is absent from the spectrum of XID-392. However, the

very limited number of counts available between 6 and 7 keV

rest frame (about four net counts in total) only allowed us to

estimate a loose upper limit for the equivalent width of the

**Q**

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# OUTFLOW characterization

• major facilities synergy to study the multiphase wind/ISM interactions in individual objects XID z logLbol logLIR SFR log(M∗) I*CO*(3−2) Mgas *µ*mol  $\lim_{s \to \infty}$ 71nd / 15ML 1nteract10ns 1 Notes: LIR is calculated in the 8-1000*µ*m range. SFR and M<sup>∗</sup> are from a Chabrier IMF. The range in gas mass and



#### • large samples to connect the presence of outflows with AGN & host properties Figure 1: Panel a,b: [OIII]5007 channel maps of XID2028 obtained integrating the continuum subtracted SINFONI datacube on the line core (a) and on the blue wing (at v*<* −500 km/s; b). The contours on the line peak, marking the position of the central QSO, are shown in black in both panels. The fully resolved, blue wing due to the outflow is extending to contract and the panel contract of position of the QSO nucleus, dominated by AGN emission (from [NII]/Hα ratios). The SF Clumps discussed in the  $f(x)$  in the  $\Lambda$   $\Lambda$   $\Lambda$   $\Lambda$  =  $\Lambda$  and  $\Lambda$  maps. Proposed scenario: the anti-correlation between scenarios and  $\Lambda$  $t$  with  $A$  and  $S$  tracers suggests the outflowing material is sweeping the outflowing material is sweeping the outflowing material is sweeping the outflowing the outflowing material is sweeping to  $t$ core ('negative feedback'), while it is compressing the gas at its edges inducing star formation ('positive feedback).  $t_{\rm eff}$  extension (blue). Black contours represent  $\epsilon$  and  $\epsilon$ beam size 4.5!!x3.4!!). The black cross marks the line centroid. The red square (3!!x3!! in size) indicates the region le presence oi outin integrated flux over the full line profile is ICO(3−2)=1.23*±*0*.*23 Jy km s−<sup>1</sup>. Figures a,b are from Brusa et al. (2015b). Panel c: Simulated CO(5-4) spectrum mimicking the flux ratios observed in the core (central gaussian) and wing (blueshifted and redshfted gaussians) components in the Cicone et al. (2014) sample (see TJ box for details). The  $\sim$  2500 F  $\Omega$  mark the sensitivity reachable with 3.8hrs exposure in channels of 100 km/s. 634 *J. R. Mullaney et al.*

 $T_{14}$ 

and Wederatel, <sup>p</sup>romoted to Pelmerande 16, Telem (see Wylezalek&Zakamska16; Balmaverde+16; Zakamska+16;  $N_{\rm 201}$  16,  $\Gamma_{\rm 202}$   $15$ ,  $\Gamma_{\rm 202}$  die 15,  $M_{\rm 11}$  data lack the resolution needed the resoluti Woo+16; Chen+15; Banerji+15; Mullaney+13;...)  $\theta$  Ronojarno's  $\ell_{\text{F}}$  Rodighiaro's talks see Bongiorno's & Rodighiero's talks e.g., L(1.4GHz), L([OIII]), SFR, sSFR, BHAR, ...

ambiguously probe  $\Lambda$ CN-galaxy coevolution. Action in action  $\Lambda$ CN-galaxy coevolution. Action is a set  $\Lambda$ CN-galaxy coevolution. Action in a set of  $\Lambda$ CN-galaxy coevolution. Action is a set of  $\Lambda$ CN-galaxy coevolutio While few other examples of 'negative feedback' in unobscured QSOs at z∼ 2*.*5 do exist and are  $M$ <sup>201</sup>i0cchatti's  $\&$ 

Mullaney+13 Mullaney+13  $\widehat{\mathbf{F}_{\mathbf{Q}}}$  2000 We will probe whether systemic the gas reservoir seen in the same spatial distribution of the SF clumps seen in the Ha image at the edge of the outflow (at  $0.4$  ) resolution; see Genzel in the outflow (at  $0.4$ et al. 2013 for a similar experiment). These regions will also be detected in the continuum, which  $nska+16$ ;  $\frac{1500}{n}$ , those will might be operations (down to  $\frac{1500}{n}$ molecular gas reservoir, extract  $\frac{1}{2}$  spectra from the clumps,  $\frac{1}{2}$  and  $\frac{1}{2}$  and kinematics, morphologies, and gas surface density;  $\geq$  inferred the  $($ relative) star formation effects in  $\sim$  $t_{\rm b}$  regions in the  $\frac{1}{2}$  regions in the  $\frac{1}{2}$  and  $\frac{1}{2}$ If the CO were distributed uniformely over the entire galaxy scale of ∼ 2x2!! (16x16 kpc), we would resolve the CO emission by slightly degrading our spectral and spatial resolution (down to 0.6!!). In any case, from the galaxy-integrated spectrum we will measure the dynamics of the host and average excitation of the gas  $(500)^2$  ratios the conservation than  $(200)^2$  $t_i = \frac{1}{\sqrt{2\pi}} \left( \frac{1}{\sqrt{2\pi}} \right)$  since of  $\frac{1}{\sqrt{2\pi}}$  in feedbacks as predicted in fe  $AGN/SF$  division(??)  $10^{40}$   $10^{41}$   $10^{42}$   $10^{43}$   $10^{44}$   $10^{45}$ Magliocchetti's & Padovani's talks [0 III] Iuminosity (ergs [O III] luminosity (ergs s<sup>-1</sup>)

clumps is converted into stars at low depletion time scales, in dense and compact gas reservoirs.

#### The X-ray/SDSS sample **TEA-RA** de-excitation rate, and explicit the dependence on the electron rate, and  $\alpha$ **P**<sub>[</sub>*OII*]  $\mathbf{V}$  are  $\mathbf{V}$  are  $\mathbf{V}$  are  $\mathbf{V}$  and  $\mathbf{V}$  are  $\mathbf{V}$  and  $\mathbf{V}$  are  $\mathbf{V}$  $55$  sawfle of previous studies it was possible to derive, although with large  $n = 1$ AGN HE X-RAY/SUSS SAMPLI mainly on the shape of the shape of the incident spectrum (and, in particular the X-ray particular the inciden<br>The incident spectrum (and, in particular the X-ray particular the X-ray particular the X-ray particular the X-

source, *N<sup>H</sup>* is the hydrogen density, and *c* is the speed of light, which is introduced to make *U*

dimensionless. Physically, *U* represents the dimensionless ratio of the density of ionizing photons

to that of neutral hidrogen. In other words, it describes how many ionizing photons there are per

nostics are pontentially usefull to measure Ne and Te because

 $\sigma_{\rm 1.5}$  their optical wavelengths  $\sigma_{\rm 2.5}$  unfortunately, the faintness of t

involved emission lines (in particular, OIII4363 and NII5755)

make difficult the measure of these quantities. The fact that the

~ 500 X-ray selected [from Georgakakis+11; Jin+12; Wang+12; Trichas+13] type 1 & type 2 AGNs ~ 500 X-ray selected [from Georgakakis+11; Jin+12; Wang+12; Trichas+13] type 1 & type 2 AGNs ionization fronts, while smaller *U* enebles several stages of ionization to coexist over large part  $\delta$ <sup>+12</sup>, Permo+10] cype  $\delta$  & cype 21101 w  $R_{\text{width}}$   $\sim$  0.8 and SNI( with  $z < 0.8$  and  $SN(OIII) > 10$  to derive general relations between  $d\phi$  and explicit the dependence on the dependence on the electron  $\phi$ *estimated because of the involved emission and outflow properties* cinematica?)  $\frac{1}{2}$  the electron Temperature. Methods to determine the electron Temperature  $\mathcal{C}^{\text{cusp}}_{\text{cusp}} = \mathcal{C}^{\text{cusp}}_{\text{cusp}} + \mathcal{C}^{\text{cusp}}_{\text{cusp}} + \mathcal{C}^{\text{cusp}}_{\text{cusp}}$  $\langle \hat{U}_1 \hat{U}_2 \hat{U}_3 \hat{U}_4 \hat{U}_5 \hat{U}_6 \hat{U}_7 \hat{U}_8 \hat$ The physical interpretation provided by diagnostic diagnostic diagnostic diagrams is contained in various specification of the specific diagrams is the contact of the specific diagrams in the contact of the specific diagra uses sensitive line ratios such as  $\mathbb{C}^3$ *A.2. [OIII] EMISSION LINES* 29  $\epsilon_{\rm so}\simeq$  with we derive a  $\epsilon_{\rm so}\simeq$  $\sim$  103 (see, e.g., Pernah, Per  $\begin{array}{|c|c|c|c|c|c|}\n\hline\n\text{R} & \text{R} & \text{R} & \text{R} \\
\hline\n\text{R} & \text{R} & \text{R} & \text{R} \\
\hline\n$ line ratios. Here we focus on the original ratios wavelengths are with the original region. One of  $\mathbb{R}^n$ electron temperature to derive the relative to derive the relative to derive the relative of  $z = 0.127$ , since the relative to derive the relative of  $z = 0.127$ , since the relative of  $z = 0.127$ , since the relative of  $z =$  $\begin{array}{c|c}\n & z = 0.127 \\
\hline\n\end{array}$  PG1115\_0\_17 of the variety of assumed N*<sup>e</sup>* values in literature. To the best of  $\sqrt{2}$  PG1115\_0\_175 the most important line ratio is the F([OIII]5007)/F(Hβ), [OIII]/Hβ for simplicity. This ratio  $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$   $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 1 \end{bmatrix}$ A.2 [OIII] emission lines estimated because of the faintness of the involved emission lines in  $\sim$ our knowledge, the electron temperature has been derived only the electron temperature  $\mathcal{A}$ regions is detected only for a small fraction of the  $A$ Figure A.3: Few temperature-sensitive ratios as a function of the electron temperature. [NII] provides into about the level of ionization about the gas. A strong  $\sim$  107 line indicates about the gas. A strong  $\sim$ (i.e., [OIII]λ and [NII]λ5755). In the best scenario, for each tarfor 6 targets (Brusa+16;Villar-Martin+14;Nesvadba+08), with ple (see below). Therefore, we choose to follow a statistical apratio is indicated with dashed line for clarity. All the analitic solutions refer to low-density relatively high level of ionization (i.e., large *U*) and large mean ionizing energy (IP(O2+)=35.12 The main forbidden emission line used the doublet throughout the doublet throughout the doublet throughout the get for with we derive data for with we should a  $\Xi$ <del>≊</del><br>T proach to try to derive the average electron temperature. The main forbidden emission line used the doublet throughout the doublet throughout the doublet throughout the regimes. electron temperature to derive the relative *Ne*. Unfortunately, sige the sense of an AGN SED. F(HB) is proportional to the number of recombination of rec De la Context de la Contexte de la Contexte de la Contexte de la Contextu de la Context The O III species is twice in the oxygen of the support of the second of the second description of the second with two electrons, which two electrons, with two electrons, with two electrons, with two electrons, with two el The large state sample collected, we are said the large sample collected, we are said the large sample The O III species is twice-induced oxygen (IP 35.12 electrons, with two electrons,  $\infty$  in the OIII4363 and  $\infty$ ions and in thus a measure of the total number of the total number of ionizing photons absorbed by the gas. This is not the gas. This is n  $T_{\text{c}}$  by  $T_{\text{c}}$  to constrain, as best we can, the both  $T_{\text{c}}$ regions is detected only for a small fraction of the AGN sam-3.3.2. The [OIII] temperature-sensitive ratio pi al lu stellal conterads. ple (see below). The following to follow a statistical appearance to follow a sta  $\frac{1}{20}$  of  $\frac{1}{3000}$   $\frac{1}{10111144363}$   $\frac{1}{4000}$   $\frac{1}{5000}$   $\frac{1}{5000}$   $\frac{1}{6000}$   $\frac{1}{5000}$   $\frac{1}{7000}$ However, from the observational point of view, [OII] are so close in wavelength that only good  $\overline{\omega}$   $\frac{3000}{100}$   $\overline{[OIII] \lambda 4363}$   $\frac{4000}{1000}$   $\overline{[OIII] \lambda 4363}$  $\omega$  3000 [OIII]λ4363 4000 5000 5000  $p = \frac{30}{100}$  $\frac{100}{\pi}$  is defined to derive the relative relative ratio. Flux  $(x10^{-17})$  $m = \frac{100}{\pi}$  is  $m = 5.8$  and can be treated as a single level. The figure level. The figure is  $\frac{100}{\pi}$  is  $100$  is  $t_{\rm H}$  is  $N_{\rm H}$  = 5.8  $\begin{bmatrix} 5.8 \end{bmatrix}$   $\begin{bmatrix} 1 \end{bmatrix}$   $\begin{bmatrix} 6300 \end{bmatrix}$  $\frac{1}{\sqrt{2}}$  in the figure and can be treated as a single level. The figure level. The figure  $\left[\frac{1}{2}, \frac{1}{2}\right]$  $A = \begin{bmatrix} 1 & 1 \end{bmatrix}$  diagnosis work at least  $\begin{bmatrix} 1 & 1 \end{bmatrix}$  and  $A = \begin{bmatrix} 1 & 1 \end{bmatrix}$ well above there is the <sup>1</sup>S<sup>0</sup> level. Energies of the order of the eV are enough to excite the O2+ emission. We find the two lines of the two lines  $\mathbb{R}^n$  $\overline{\mathbf{3}}$  and  $\overline{\mathbf{3}}$  density-s  $\sum_{\mathbf{z}}$  80 iii,  $\mathbf{w}$   $\mathbf{A}$  is the level of ionization than the function  $\mathbf{A}$  in  $\mathbf{A}$  $\mathbb{E}$  is the 1S0 level. In the 1S0 level. Energies of the enough to excite the  $\mathbb{R}$ characterized by densities not greatly in  $\mathbb{R}$ . The Number of the Number  $\mathbb{R}$  $\approx$  imposed the same systemic s  $\sum_{i=1}^{\infty}$  is property in Fig. (O III] $\lambda$ 5007 and  $\sum_{i=1}^{\infty}$  and  $\sum_{i=1}^{\infty}$  $\sim$   $\frac{1}{\sqrt{2}}$  in the interaction potentials are nearly equal to the second  $\sim$  10.50 eV, to to the interaction of  $\sim$  10.59 eV, to the interaction of  $\sim$  10.59 eV, to the interaction of  $\sim$  10.59 eV, to the intera  $T_{\text{max}}$  $\sim$  60  $\sim$  60  $\sim$  60  $\sim$  50  $\sim$  ions. The relative number of [O III]λ5007 and [O III]λ4959 photons is set by the ratio of their  $\bowtie$  60  $\sim$   $\frac{10}{3}$   $\frac{1300}{4300}$  (Since  $\frac{1}{3}$ ) associated A-values (i.e., = 2.9; Osterbrock & Ferland 2006) and is responsible of the familiar  $\sum_{\text{H}\nu\lambda4342}$  $\overrightarrow{H}$   $\overrightarrow{H}$   $\overrightarrow{A}$   $\overrightarrow{A}$   $\overrightarrow{A}$  $\begin{array}{|c|c|c|c|c|c|} \hline \hline \textbf{W} & \textbf{[SII]}\lambda\lambda 6716,6731 \hline \end{array}$  $\equiv$  Hγλ4342  $A_4$   $A_5$   $A_6$   $A_7$   $A_8$   $A_9$   $A_9$  $\begin{array}{ccc}\n\mathbb{E} & \mathbb{E}^{(\mathcal{Y} \mathcal{A} + \mathcal{S} + \mathcal{Z})} \\
\mathbb{E} & \mathbb{E}^{(\mathcal{Y} \mathcal{A} + \mathcal{S} + \mathcal{Z})}\n\end{array}$  $\begin{bmatrix} \Box & \Box Y \Lambda + J + Z \ \Box & 40 \end{bmatrix}$  $\begin{array}{ccc} \hline \text{F1} & \text{F2} & \text{F3} & \text{F4} \end{array}$ infer that the  $\mathbb{E}$  and  $\mathbb{E}$  is a strong in the outer part of the ionization of the ion **F**(*N*<sup>P</sup>(1)/*F*(λ<sub>67</sub>31); Osterbrock 1989). We measured the NLRS 1989). We measured the NLRS 1989 emission. We fix the two lines. For all targets  $40\frac{1}{\epsilon}$  $\mathbb{R}^1$  that showed evidences with S/N that showed evidences of outflows of outflows of outflows of outflows of outflows of  $\mathbb{R}^1$  $HBA4861,$ *R*  $R$   $\cup$   $R$   $\cup$  we impose the systemics of  $\Gamma$  $\mathbb{R}$  is particle particle in the reason is the final photons emitted phot  $\mathcal{L}_{20}$   $\vdash$   $\mathcal{H}_{\beta\lambda4861}$   $\mathcal{H}_{\beta\lambda}$  $\begin{bmatrix} 20 & \text{H}\beta\lambda4861 & \text{V}\end{bmatrix}$ components as  $20 - \frac{11}{10} \lambda +$ Hander Hander (See, e.g., the third row of Fig. fits of Fig. fits of The third row of Fig. fits of The third row of decrease the photons of the Magnus of the Magnus of the Holy into the region where we are a second the region of the region the same point with sources to 18 targets: 19 targets: 19 targets: 10 ( S/Note 1919) procession movement was are for the captures of the captures of the case of th  $\mathcal{A}$ a. 1 a.2.1 as tracer of ionized outflowing gas tracer of ionized outflowing gas tracer of ionized outflow more importantly, without outflows revealed in simultaneous fits. most of the oxygen is neutral and the sulfur and nitrogen are singly ionized and excite them. 8 (S/N≥10) sources fitted with NC+OC. The ratio distributions by downward radiative transitions to the ground level. As the atomic structure of hydrogen  $\frac{1}{4600}$  and  $\frac{1}{4600}$  and  $\frac{1}{48}$ 6800  $f_{\text{600}}$  the NC and  $f_{\text{600}}$  are shown in Fig. 5, right in Fig issue that state street which were viewed as a street can be well determined the stree This phenomenon is especially in the one of th  $y_0$  that showed evidences with S/N that showed evidences of outflows of outflows of outflows of outflows of  $\mathcal{N}$ Rest Wavelength (Å) th  $(\rm \AA$  ) (black and blue shaded areas, respectively). equations. The result is result for the resulting  $\left($ A  $\right)$  $\frac{1}{\sqrt{2}}$  in the brighter emission lines (e.g.,  $\frac{1}{2016}$ in Line<br>in Line<br>Mondav October 10, 2016 **j**(*Te* = 104*K*) ≈ *j(Te* = 104*K*) ≈ *j(Te* = 102*cm*−3) ≈ 3.5 ×

 $t$ <sub>18</sub> targets: 10,  $\epsilon$ 0  $\epsilon$  $Solution 10, 2016$ weakly dependent on the local conditions (i.e.  $\frac{1}{2}$ ). In particular, two cases exists for  $\frac{1}{2}$ Monday, October 10, 2016

*R*[*OIII*] = [*F*(λ5007) + *F*(λ4959)]/*F*(λ4363) (12)

1 + 3.77*x*

*Te* = 32900/*ln*(*R*[*OIII*]/7.9) (13)

temperature. Methods to determine the electron Temperature

where x= 0.01 *Ne*/

*R*[*S II*] = *F*(λ6716)/*F*(λ6731) = 1.49

### x-ray/sdss sample-OUTFLOW INCIDENCE median values of ≈ 5% and ≈ 20% of the Hα and Hβ fluxes. In **particular, as expected, they are not incredible the narrow components.** Figure 4 shows the BPT diagrams obtained from  $\sim$  shows the BPT diagrams obtained from  $\sim$  $\mathbb{R}$  T It is interesting that high-resolution observations of many nearby AGN (e.g., ) show that  $\sim$  in the ionization cones of the  $\sim$  is often not aligned with the minor axis of the minor axis of the  $\sim$   $\sim$ GUIFLOW, INCIDENCE disk of the host galaxy. This scenario open to possible misunderstanding to possible misules and the structure<br>This structure of the stru *A&A proofs:* manuscript no. RoiiiRsii\_v1

#### $\frac{1}{2}$ 10IIIZed component - [OIII]5007 in **ionized component - [OIII]5007 line** complex systems: it is discriminate between a galaxy-scale absorber and the presence  $\mathbf{r}$ onized component - [OIII]5007 line In the presence of a torus may be supposed that even the presence of a torus may be questionable in the immediate,  $\mathcal{L}(\mathcal{L})$  $\frac{1}{2}$ ionized component.  $\Omega$ formede component ton

median values of ≈ 5% and ≈ 20% of the Hα and Hβ fluxes. In • ~40% shows signature ionized outflows  $10<sub>W</sub>$  about giove duration distribution properties. • ~40% shows signature ionized outflows  $220^\circ$  blue vince envealing flower  $\frac{32\% \text{ blue wings} - \text{approaching flows}}{2500}$  32% blue wings - approaching flows 2500  $\frac{32}{6}$  biddewings - approaching flows  $\frac{1}{2000}$  ordering approaching now  $\frac{2500}{2000}$  $2000$ and the corrections of Type-1 and Type-1 and Type-1 and Type-2 and Type-2 and Type-2 and Second stellar features, for both stellar features, and second stellar features, for both stellar features, for both stellar features (same fraction in Veron-Cetty+2001; Woo+16; ...) 2000 **•** Outflow fraction increases w/ Luminosity  $\frac{1}{\sqrt{2}}$  of  $\frac{1}{\sqrt{2}}$   $\frac{1}{\sqrt{2}}$   $\frac{1}{\sqrt{2}}$   $\frac{1}{\sqrt{2}}$   $\frac{1}{\sqrt{2}}$   $\frac{1}{\sqrt{2}}$  of  $\frac{1}{\sqrt{2}}$ of absorbing could be expected increases w/ Luminosity  $\frac{1}{2}$  1500  $\frac{1}{2}$   $\frac{1}{2}$  1500 our following analysis 45 targets (marked with red crosses in the SF galaxies from galaxies containing AGN (Eq. 1 of Kewley et (Merloni+14). These findings suggest that the single unified model based solely on orientation  $1000$ 1000  $7000 - 1000$ **•** Fraction > 50 % in QSO-Luminosity regime  $L_{[OIII]} \approx 10^{42} \text{ erg/s}, \text{ i.e. } L_{bol} \approx 10^{45} \text{ erg/s}$ 500 500  $L_{[OIII]} \approx 10^{42} \text{ erg/s}, \text{ i.e. } L_{bol} \approx 10^{45} \text{ erg/s}$ <br>(same threshold in Veilleux+13: Zakamska & Greene (same threshold in Veilleux+13; Zakamska & Greene 14; Woo+16)  $t_{\text{same}}$  threshold in veilleux+13; Zakamska  $\&$  Greene more scattered because of their associated because of their associated lower intensities: this intensity intens<br>The intensities: this intensity is the intensity intensity in the intensity intensity in the intensity intensi 40 42 44 erg/s). We note that the exclusion of the exclusion of the exclusion of the exclusion of few targets above the<br>The exclusion of the exclu  $/$  [erg/s]) determine an important degeneracy in the fit results, in particu $log(L_{[OIII] (NC+OC)}$ theoretical transitional curve is due to a conservative approach

SF galaxies from galaxies containing AGN (Eq. 1 of Kewley et

absorption features can actually determine under the state of the state of the state of the state of the state<br>The state with the state of the

al. 2013). For almost all the sources, the systemic NC and the OC

### x-ray/sdss sample-OUTFLOW INCIDENCE  $\mathsf{L}$  $\overline{A}$ structure of complex systems: it is difficult to discriminate between a galaxy-scale absorber

and the presence of a torus, which as well responsible for  $\mu$  signatures typical responsible for  $\mu$  signatures typical responsible for  $\mu$ 

#### **ionized component - [OIII]5007 line**  $\ddot{\phantom{a}}$ pond ze  $\mathbf{L}$  $\overline{\mathbf{inmize}}$ former bestionized component [OIII] formed component - foun  $\alpha$  is a source  $\alpha$  sources. IN INTERACTIC to be reduced by  $\alpha$ omzeu component - [OIII]5007 inie

**• •**  $\sim$  40 % shows signature ionized outflows  $\frac{100}{\pi}$  $\frac{10}{6}$  $\bullet$   $\sim$  40 %  $\sim$  40 % shows signature ionized outflows

32% blue wings - approaching flows 7% red wings - receding flows (same fraction in Veron-Cetty+2001; Woo+16)  $\frac{32\%}{701}$  b  $\frac{1}{\theta}$  (same fr  $\frac{1}{2}$  $\frac{32}{0}$  both correction from stellar from stellar from stellar features, for both stellar stellar stellar features, for  $\frac{70}{0}$  rection from stellar stellar stellar stellar stellar stellar stellar stellar stellar st  $\frac{1}{\sqrt{1-\frac{1}{$  $\frac{1}{\alpha}$  (same fraction in Veron-Cetty+2001; Woo+16)  $32\%$  blue wings - approaching flows  $2500$  $\frac{1}{2}$  $\frac{32}{6}$  bitte wings - approacting flows<br>  $\frac{7\% \text{ red wings - receding flows}}{7\%}$ 

**• Outflow fraction increases w/ Luminosity** of components must be taken into account. We excluded from **•** Outflow  $\overline{\phantom{a}}$   $\overline{\phantom{a}}$  $\frac{1}{\sqrt{2}}$  $\int_0^1$  Outflow fraction increases w/I uninosity SAF GALAXIES FROM ANGLES CONTAINING Moreover, the Moreover, the X-ray spectra of a large number of a large number of a large 2 AGN do not indicate large number of a large number of a large spectra of a large number of a large number of a large number of a l

1500

• Fraction > 50 % in QSO-Luminosity regime (same threshold in Veilleux+13; Zakamska & Greene 14; Woo+16) figure) (ma mancano Lx T13). For these sources, the SF na**ture highlighted by the BPT** diagrams, has been confirmed by the BPT diagrams, has been confirmed by  $L_X \sim 10$ <br>(same thr (same threshold in Veilleux+13; Zakamska & Greene 14; Woo+16)  $\overline{\phantom{a}}$  $L_{\rm x} \approx 10$  $\frac{1}{\sqrt{2}}$  (same thrown)  $\overline{\phantom{a}}$ are consistent with an AGN consistent with an AGN consistent with an AGN consistent with an AGN consistent with a  $L_{\rm x} \approx 10^{44}$  erg/s Fraction  $>$  50  $\%$  $L_X \approx 10^{44}$  erg/s, i.e.  $L_{bol} \approx 10^{45}$  erg/s



1500

determine an important degeneracy in the fit results, in particu-

lar for type 1 AGNs (blue circles) for type 1 AGNs (blue circles) for which and type 1 AGNs (blue circles) for<br>The circles of the c

absorption features can actually determine under the state of the state of the state of the state of the state<br>The state of the st

median values of ≈ 5% and ≈ 20% of the Hα and Hβ fluxes. In

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SF galaxies from galaxies containing AGN (Eq. 1 of Kewley et

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al. 2013). For almost all the sources, the systemic NC and the OC

median values of ≈ 5% and ≈ 20% of the Hα and Hβ fluxes. In

<1042 erg/s). We note that the exclusion of few targets above the

determine an important degeneracy in the fit results, in particu-

theoretical transitional curve is due to a conservative approach

lar for type 1 AGNs (blue circles) for which an higher number

 $\mathbf{f}(\mathbf{r},\mathbf{r})$  shows the BPT diagrams obtained from obtained from obtained from our spectro-

## x-ray/sdss sample-**OUTFLOW INCIDENCE** structure of complex systems: it is difficult to discriminate between a galaxy-scale absorber  $\mathbf{I}$

and the presence of a torus, which as well responsible for  $\mu$  signatures typical responsible for  $\mu$  signatures typical responsible for  $\mu$ 

### **ionized component - [OIII]5007 line** ionized component [OIII] formed component - foun  $\alpha$  is a source  $\alpha$  sources. IN INTERACTIC to be reduced by  $\alpha$ omzeu componem - [Omjou07 inie

• ~40 % shows signature ionized outflows

2000

 $\frac{1}{2}$  $\frac{32}{6}$  bitte wings - approacting flows<br>  $\frac{7\% \text{ red wings} - \text{receding flows}}{2000}$  $\frac{1}{\alpha}$  (same fraction in Veron-Cetty+2001; Woo+16) 32% blue wings - approaching flows 2500 (same fraction in Veron-Cetty+2001; Woo+16) 2000

SAF GALAXIES FROM ANGLES CONTAINING **• Outflow fraction increases w/ BH mass**  $\ddot{\phantom{0}}$ 

1500

 $\overline{P}$  . The single sources, the systemic  $\overline{P}$ Fraction  $>$  50 % in more massive bills<br> $L_{\rm x} \approx 10^{44}$  erg/s, i.e.  $L_{bol} \approx 10^{45}$  erg/s (same threshold in Veilleux+13; Zakamska & Greene 14; Woo+16) • Fraction > 50 % in more massive BHs  $L_X \approx 10^{44}$  erg/s, i.e.  $L_{bol} \approx 10^{45}$  erg/s



1500

determine an important degeneracy in the fit results, in particu-

lar for type 1 AGNs (blue circles) for type 1 AGNs (blue circles) for which and type 1 AGNs (blue circles) for<br>The circles of the c

absorption features can actually determine under the state of the state of the state of the state of the state<br>The state of the st

median values of ≈ 5% and ≈ 20% of the Hα and Hβ fluxes. In

# x-ray/sdss sampleoutflow incidence

*A&A proofs:* manuscript no. RoiiiRsii\_v1



- **•** observed in high S/N spectra of low-luminosity /obscured AGNs
- AGN radiation can easily ionize the neutral gas
- both ISM and stars contribute to NaID abs. line

# x-ray/sdss sampleoutflow incidence

*A&A proofs:* manuscript no. RoiiiRsii\_v1



Monday, October 10, 2016

# x-ray/sdss sampleoutflow incidence

## *A* neutral component - Na I D abs.line



2000  **<1 % shows signature of neutral outflows (see also Sarzi+16)**

## **OUTFLOW PROPERTIES** 10[*<sup>O</sup>*/*H*]−[*O*/*H*]<sup>⊙</sup> *j*[*OIII*] < *Ne* >

*<sup>M</sup>*˙ *out* <sup>∝</sup> *MoutVout*/*<sup>R</sup>* (3)

*L*[*OIII*]

*OUTHOW mass rate:*<br>  $\frac{1}{2}$  ≤

$$
\dot{M}_{out} \propto M_{out} V_{out}/R
$$

kinetic power:

$$
\dot{E}_{out} \propto \dot{M}_{out} V_{out}^2
$$

for the [OIII]λ5007 line:

momentum flux:



 $P_{out} \approx L_{bol}$  (*Molecular out jlows*)  $P_{out} \approx L_{bol}/c$  (*Ionised out jlows*)<br>  $\dot{P}_{out} \approx 10 - 50 L_{bol}/c$  [*Molecular out flows*] *LA*<br>
Divideo is the contract of the contract of the metal-term is the metal-term of the metal-term is the metal- $\dot{E}_{out} \approx 1 - 5\% L_{bol}$  [Molecular out flows]  $\dot{P}_{out} \approx L_{bol}/c$  [Ionised out flows]  $\dot{E}_{out} \approx 0.05 - 0.1\% L_{bol}$  [Ionised outflows]  $\dot{P}_{out} \approx 10 - 50 L_{bol}/c$  [Molecular outflows]  $\dot{E}_{out} \approx 1-5\%L_{bol}$  [Molecular outflows]  $\dot{P}_{out} \approx L_{bol}/c$  [Ionised outflows] We note that the wing to lower ratios is due only to the higher

*<sup>P</sup>*˙ *out* <sup>≈</sup> <sup>20</sup>*Lbol*/*<sup>c</sup>* [*Molecular out f lo*w*s*] (9)

 $z$  sources in the sample. The sample  $\mathcal{L}$  sources in the sample. Their lower S/N spectra (see Fig. 1), can be

where *mp* is the proton mass, *C* =< *Ne* ><sup>2</sup> / < *N*<sup>2</sup>

### ionized mass outflow **MASS OUTFLOW** bidden [OIII]<br>https://www.are generally used to derive such quantities, because they are they are they are they are they are 10[*O/H*−[*O/H*]<sup>⊙</sup> *j*[*OIII*] *< N<sup>e</sup> >*

We may estimate the mass and the size of the emitting gas starting from the luminosity of

· To derive outflow energetics, several critical assumptions are required, making the comparison with model predictions very difficult. where *C* =*< N<sup>e</sup> >*<sup>2</sup> */<N*<sup>2</sup> *required* making the comparison with model prodictions very *required, making the comparison with model predictions very*<br>difficult temperature and density of the gas, but also to the abundance.

 $M_{ion}(H\beta) \approx 0.8 \frac{P}{j_{H\beta} < N_e>} \frac{M_{\odot}}{N}$  (see, e.g., Cano-Diaz+12; Carniani+15; Cresci+15)  $M_{ion}([OIII]) = 1.7 \times 10^3 \frac{m_p CL_{[OIII]}}{10^{[O/H - [O/H]_{\odot}} i_{[OIII]}}$  $10^{[O/H-[O/H]_{\odot}} j_{[OIII]} < N_e >$  $M_{\odot},$ and [*O/H* − [*O/H* − [*O/H*]⊙ is the metallicity relative to solar. Note that the gas mass is sensitive to sensitive to solar mass is sensitive to solar metallicity relative to solar mass is sensitive to sensitive to sen  $M_{ion}([OIII]) = 1.7 \times 10^{9}$  $M_{ion}(H\beta) \approx 0.8$  $m_p CL_{H\beta}$  $j_{H\beta} < N_e$  $M_{\odot}$  (500,000 Cano Diaz<sup>112</sup>: Camiani 15: Cross

Assumptions are usually required for  $\Delta$  estimations are usually required for responsible for the narrow-emission gas assuming a spherical distribution and typical plasma

unit studies (McElroy). This gas can not be under the gravitational influence of the gravitational influence o<br>Discoveries (McElroy)

black hole and is therefore the part of the part of the part of the host galaxy interstellar medium photoioniz<br>When the host galaxy interstellar medium photoionized by the host galaxy interstellar medium photoionized by t

where  $\mu$ <sub>β</sub> is the Hβ is the Hβ luminosity and  $\mu$ β is the emission is a better tracer trace

bidden [OIII] are generally used to derive such the strongest to derive such quantities, because they are the

lines in AGN spectra and do not suffer for particular blending problems. The ionized gass mass

• the metallicity term (see Perna+15) *Mion*(*H*β) ≈ 0*.*8 **•** the metallicity term (see Perna+15)

temperature and density of the gas, but also to the abundance.

• the emissivity j, weakly dependent on Ne and Te in the outflowing regions **F**<br> **e the emissivity 1** weakly dependent on Ne and Te in the outflowing *M*<sup>⊙</sup> (5) **L**<br>H**P**B is the H**Bis the HBis the emission is a better tracer trace** From this computation we derived typical values for the extension of the narrow-line gas.

properties from Eq. 5, i.e. without any assumption regarding the metallicity: *Mion* ≈ 10<sup>7</sup> M<sup>⊙</sup>

• the average Ne **Such extensions have been confirmed by long-slit spectroscopy** (Hainline 14) and integral field  $\mathbf{r}$  $\bullet$  the average  $Ne$ responsible for the narrow-emission gas assuming a spherical distribution and typical plasma

found in the Appendix.

Ionized gas Mass and Size

can be obtained from the from the from the from the equation of the equation of the equation of the equation of<br>The equation of the equation o

# electron density and temperature Assumptions

• Different assumptions for Ne and Te are used in the literature to derive mass outflow, mostly based on few estimates.

## **Ne measurements ( assuming Te=10'000 K ) :**

```
Rodriguez-Zaurin+13 (Ne > 4'000 cm<sup>-3</sup>)
Harrison+12 (Ne = 500 cm^{-3} [ULIRGs staked spectrum])
Harrison+14; Westmoquette+12 (Ne = 200-1000 cm<sup>-3</sup>)
Genzel+14 (Ne = 80 cm<sup>-3</sup> [SF-ionized gas ])
Perna+15 ( Ne = 120 cm^{-3} [ single obj ])
...
```
## **Ne + Te measurements**

Brusa, MP+16 ( $Ne = 780$  cm<sup>-3</sup>; Te = 13'000 [single obj ]) Villar Martin+14 ( Ne =  $800-3'200$  cm<sup>-3</sup>; Te  $\approx 16'000$  [ 4 obj ]) Nesvadba+08 (  $Ne = 500$  cm<sup>-3</sup>; Te  $\approx$  11'000 K [ single obj ] )

#### **P P P P ELECTRON DENSITY AND** temperature Assumptions *<sup>P</sup>*˙ *out* <sup>≈</sup> <sup>10</sup> <sup>−</sup> <sup>50</sup> *Lbol*/*<sup>c</sup>* [*Molecular out f lo*w*s*] (10) JENSIIY AND fit results. ASSUMPTIONS have focused our analysis on the simple specific our analysis on the simple specific specific specific specifi<br>As a substantial specific spec *L*[*OIII*] is the [OIII]λ5007 luminosity, 10[*<sup>O</sup>*/*H*]−[*O*/*H*]<sup>⊙</sup> is the metallicity, *j*[*OIII*] the emissivity. This last term is weakly dependent TEMDEDATIIDE ACCII IEMFERAIURE ASSU fit of the [OIII] lines, well defined [SII] wings) and, as before,  $\overline{A}$ ND. Although the large number of large  $\overline{A}$ targets with intense [SII] emission, only 28 targets satisfy the ABTIONS xx. From this sample, we computed the *R*[*S II*] for both NC and xx. From this sample, we computed the *R*[*S II*] for both NC and ELECIRON DENSIIY AND TEMPERATURE ACCUMPTION IEMFERAIURE ASSUMFIIUN EI FCTRON DENSITY fit results. TEMDEDATIIDE ACCIIME have focused our analysis on those AGNs with the simplest spec-

above mentioned conditions. The fitted spectra are shown in fig. , we can also spectra are shown in fig. ,  $\alpha$ 

We note that the wing to lower ratio the wing to lower ratio the higher ratio to the wing to the higher ratio to

tral profiles (i.e. only two kinematic components revealed by the

tantly, the outflow mass show an inverse proportionality to the

We note that the wing to lower ratios is due only to the higher

tral profiles (i.e. only two kinematic components revealed by the

temperature. Methods to determine the electron Temperature

• Plasma diagnostics can be used to derive outflow Te and Ne (Osterbrock & Ferland 2006), but great challenges preclude their adoption.  $t_n$  decime entitles  $T_n$  and  $N_n$  (Ostarburgh  $e$  $\sigma$  defive outflow the and the (OSIEIDIOCK  $\alpha$ • Plasma diagnostics can be used to derive outflow Te and Ne (Osterbrock &  $\frac{1}{2006}$  Ferland 2006). but great challenges preclude their  $\frac{1}{2}$  chana 2000), D'at france chanel 18<sup>00</sup> Precidae them OC. The NC *R*[*S II*] distribution (fig 5, left black curve) has a option. Ferland 2006), but great challenges preclude their adoption. Ferland 2006), but great challenges preclude their adoptic targets with intense  $S$  is the started satisfy the started sa



*<sup>e</sup>* >,

on electron density but could determine uncertainties of a factor

of three if the temperature if wrongly assumed2. More impor-

*<sup>P</sup>*˙ *out* <sup>≈</sup> *Lbol*/*<sup>c</sup>* [*Ionised out f lo*w*s*] (9)

*<sup>P</sup>*˙ *out* <sup>≈</sup> <sup>10</sup> <sup>−</sup> <sup>50</sup> *Lbol*/*<sup>c</sup>* [*Molecular out f lo*w*s*] (10)

where *mp* is the proton mass, *C* =< *Ne* ><sup>2</sup> / < *N*<sup>2</sup>

*L*[*OIII*] is the [OIII]λ5007 luminosity, 10[*<sup>O</sup>*/*H*]−[*O*/*H*]<sup>⊙</sup> is the metal-

licity, *j*[*OIII*] the emissivity. This last term is weakly dependent

to derive these properties in regions with densities ! 104 cm−<sup>3</sup>

tantly, the outflow mass show an inverse proportionality to the

electron density. Outflow energetics are usually derived assum-

ing given values for electron temperature and density. While a

general consensus is found for a T*<sup>e</sup>* = 104 K (e.g., Harrison+14;

. . ), see electron density: for  $\mathcal{S}$ 

Cano-Diaz+12 assumed 1000 cm3, Carniani+15 500 cm3 and

to derive these properties in regions with densities ! 104 cm−<sup>3</sup>

(depending on the critical density of the involved forbidden tran-

sitions). In particular, [SII]λλ6716,6731, [OIII] and [NII] diag-

nostics are pontentially usefull to measure Ne and Te because

of their optical wavelengths3. Unfortunately, the faintness of the

involved emission lines (in particular, OIII4363 and NII5755)

make difficult the measure of these quantities. The fact that the

OC are generally fainter that the NLR ones, makes further dif-

ficult to derive such diagnostic informations. Only for a handful

of previous studies it was possible to derive, although with large

uncertainties, these quantities. These works are generally based

on single luminous targets (e.g., Perna+15;Brusa+16) or, in the

Few diagnostic ratios involving forbidden lines can be used

### electron temperature ESTIMATE  $\Gamma$  a: BPT diagnostic diagrams – Standard diagrams – Standard diagnostic diagrams – Standard diagram showing the classification scheme by Kewley et al. (2013). The lines drawn in  $\mathcal{M}_\text{c}$ EI FCTRON TEMPERATURE galaxies from galaxies from galaxies containing AGN (Kewley et al. 2013). Black and blue systemic NC and outflow OC flux ratios, respectively. Representative error bars are shown only for an small fraction of targets. Circles, squares and triangles denote Type 1, type 2 and type 1.9 AGNs respectively. Red crosses highlighted the SFGs discarted the SFGs discarted the sample. Red crosses highlighted the SFGs discarted from the sample. The SFGs discarted from the sample relatively close in wavelength, no correction for extinction are needed.  $F_{\rm eff}$  is that, been that, been the that, been relatively close in wavelength, no correction for extinction are

ple curves). The curves of the curves of



Fig. 5: (*left:*) [SII]λλ6716,6731 ratio distributions. The grey solid line mark the distribution for the AGN sample without evidence

though with large uncertainties, though with large uncertainties, the outflow condition estimates of  $\alpha$ 

cal classification scheme of Keylew-06,13: in the second BPT, in the second BPT, in the second BPT, in the second B<br>The second BPT, in the second

### ELECTRON DENSITY ESTIMATE relatively close in wavelength, no correction for extinction are can be seen for the large sample studied by Zhang+2013, for Fig. 4: BPT diagrams – Standard diagnostic diagram showing the classification scheme by Kewley et al. (2013). The lines drawn in I DENCITY CORRESPOND TO THE THEORETICAL REDSHIFT-DEPTH CORRESPOND TO THE THEORETICAL REDSHIFT-DEPTH CURVES AT galaxies from galaxies containing AGN (Kewley et al. 2013). Black and blue systemic NC and outflow et al. 2013 OC flux ratios, respectively. Representative error bars are shown only for an small fraction of targets. Circles, squares and triangles denote Type 1, type 2 and type 1.9 AGNs respectively. Red crosses highlighted the SFGs discarted from the sample.



needed.

## **RESULTS**

- We found signature of ionized outflows in 40% of X-ray selected AGNs.
- The fraction of outflows is  $> 50\%$  in the QSO-luminosity regime
- The almost total absence of neutral outflows may be due to observational limitations / the presence of high ionized radiation from AGNs (see also Villar-Martin+14 {1/22 shows neutral outflow}).
- We derive the first average estimates of outflowing plasma properties, for a medium size sample ( $\sim$  40 targets).
- We suggest that similar electron temperatures could be present in NLR and outflowing regions (  $Te[OC] \sim Te[NC] \sim 17'000 \text{ K}$  ).
- Outflowing gas is characterized by electron densities ~ 2 times those of the NLR ( Ne[OC] ~ 1'000 cm **-3** )
- NLR estimates are consistent with previous results (Xu+07; Zang+13; Vaona+12)