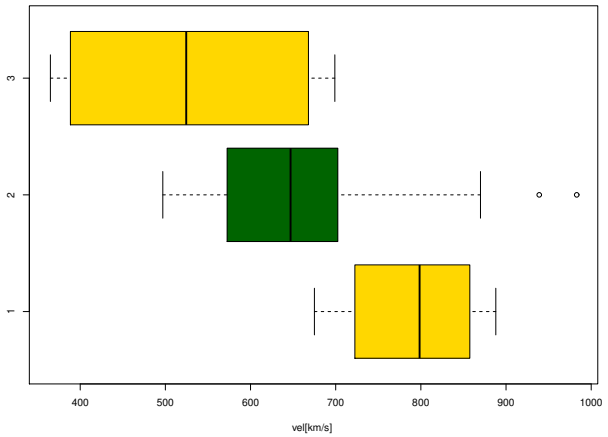

Fig. 1. Statistical significance of the shifting of the X-ray lines found in the spectrum of NGC 3783. Each box is made of five-number summaries: the smallest observation (sample minimum, which are the thin bars at the extreme left of each box), a lower quartile (Q1, which is the left thick border of each box), the median (Q2, black thick vertical line), the upper quartile (Q3, the right thick border of each box) and largest observation (sample maximun, which are the thin bars at the extreme right of each box).

the final physical solution in § 6. We summarize in § 7.

2. SIGNIFICANCE OF THE SHIFTING IN THE X-RAY LINES

Since our analysis searches for possible correlation between the ionization state of the ions forming the absorption lines observed in the X-ray spectrum of this object, and the Doppler velocity shift of those lines, we first study the statistical significance of this possible shifting. A convenient way to do this is through the separation of the ions into groups to search for the velocity shifting. We take all the ions we find in Table 3 (see Table 3 below). The line's centroids are taken from Kaspi et al. (2002). The ionization fraction curves for the classification are taken from Kallman & Bautista (2001); Bautista & Kallman (2001). Afterwards we collect them into three groups[1]: Group 1, representative of all ions of low ionization with ionization parameter $0 < \xi(\mathrm{erg\ cm\ s^{-1}}) < 10$; Group 2, $10 < \xi(\mathrm{erg\ cm\ s^{-1}}) < 250$, representative of intermediate ionization state; and Group 3, $250 < \xi(\mathrm{erg\ cm\ s^{-1}}) < 650$. A graphical way to represent this grouping scheme is shown in Figure 1. Each box is made of five-number summaries: the smallest observation (sample minimum, which is the thin bar at the extreme left of each box); a lower quartile (Q1), which is the left thick border of each box; the median (Q2), the black thick vertical line; upper quartile (Q3), the right thick border of each box and largest observation (sample maximum) which is the thin bar at the extreme right of each box. The first conclusion is that all three Q2s are different. It is clear that Groups 1 and 3 are different at $\gtrsim 1\sigma$. There is overlap between Groups 1 and 2 (possibly due to limited resolution of the instrument), but Groups 2 and 3 are different at $\gtrsim 1\sigma$. We continue our analysis bearing in mind these overlaps in the groups.

[1]We group and generate the figure using the statistical package R (`http://www.r-project.org`).

3. METHOD

Let us consider a radiation source with $L \sim 10^{44} - 10^{47}$ erg s^{-1}, arising from a supermassive ($\sim 10^8\ M_\odot$) black hole (BH). Material $\sim$0.1–1 pc from the BH only needs to absorb a small fraction of this energy to be accelerated to few thousand km s^{-1} in Seyfert galaxies and up to 0.1–0.2 c in high redshift Quasars (Arav, Li, & Begelman 1994; Ramírez 2008; Saez, Chartas, & Brandt 2009; Chartas et al. 2009). By conservation of mass the number density of hydrogen can be written, assuming spherical symmetry, as

$$n_H(r) = \frac{\dot{M}}{4\pi r^2 v(r) \mu m_H}, \qquad (1)$$

where $\dot{M}$ is the mass-loss rate, $v(r)$ is the outflow speed at radius r, μ is the mean atomic weight per hydrogen atom and m_H is the hydrogen mass.

We adopted a velocity law $v(r)$ compatible with the predictions of the radiatively driven wind theory (Castor et al. 1975). The velocity law has two fundamental roles. The first is to shift the frequency of the absorbing lines according to the Doppler effect. The second is to dilute the gas density, affecting radiative transfer across the gas and consequently the ionization and thermal state of the gas. The velocity law varies with distance as

$$w(x) = w_0 + (1 - w_0)\left(1 - \frac{1}{x}\right)^{\beta}. \qquad (2)$$

Here, w is the velocity normalized to the terminal velocity of the wind v_∞, w_0 is the velocity in the base of the wind and x is the distance normalized to the radius of the central core r/r_0. The parameter β is the quantity governing the slope of the velocity with the distance and its *ad hoc* value depends on the type of radiative force acting on the wind. Analysis of hot stars suggests that $0.5 \lesssim \beta \lesssim 1$ (Lamers et al. 1987). The evaluation of radiation-driven wind in AGNs of Drew & Giddings (1982),