

# Multiwavelength Campaign on NGC 7469: Photoionisation Modelling of the Emission Line Regions

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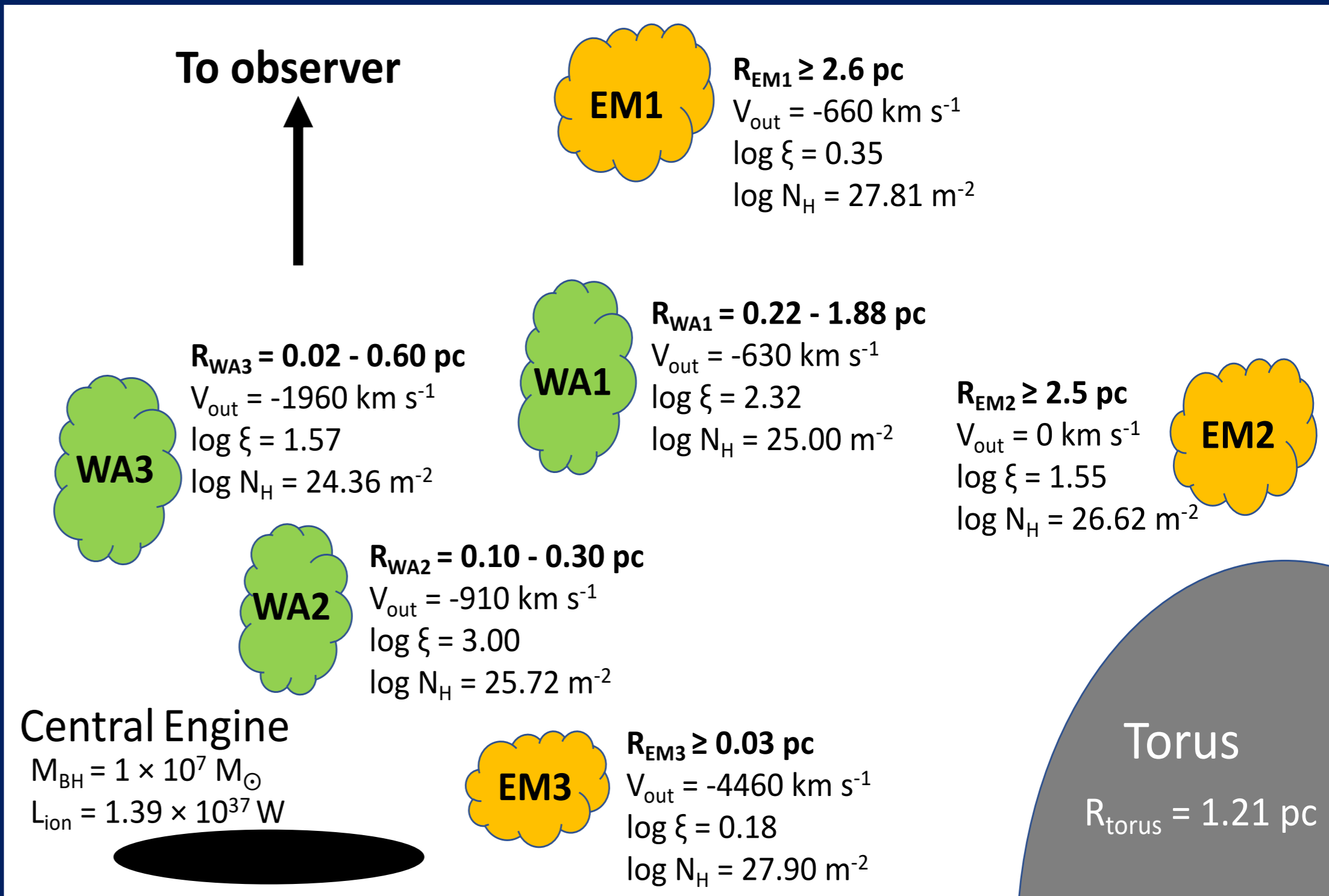
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## Abstract

The Seyfert 1 galaxy NGC 7469 was the target of an extensive observing campaign with XMM-Newton in 2015. Analysis of the 640 ks RGS spectrum with the spectral fitting code SPEX, and the physically self-consistent photoionisation model PION, shows that the emission line region (ELR) is multi-phased, while still accounting for three warm absorber (WA) components. We discuss how adjusting the volume filling factor ( $C_v$ ) could resolve the differences of distance estimates obtained from variability arguments. Further comparisons made with other AGN (NGC 5548 and NGC 3783) are presented.

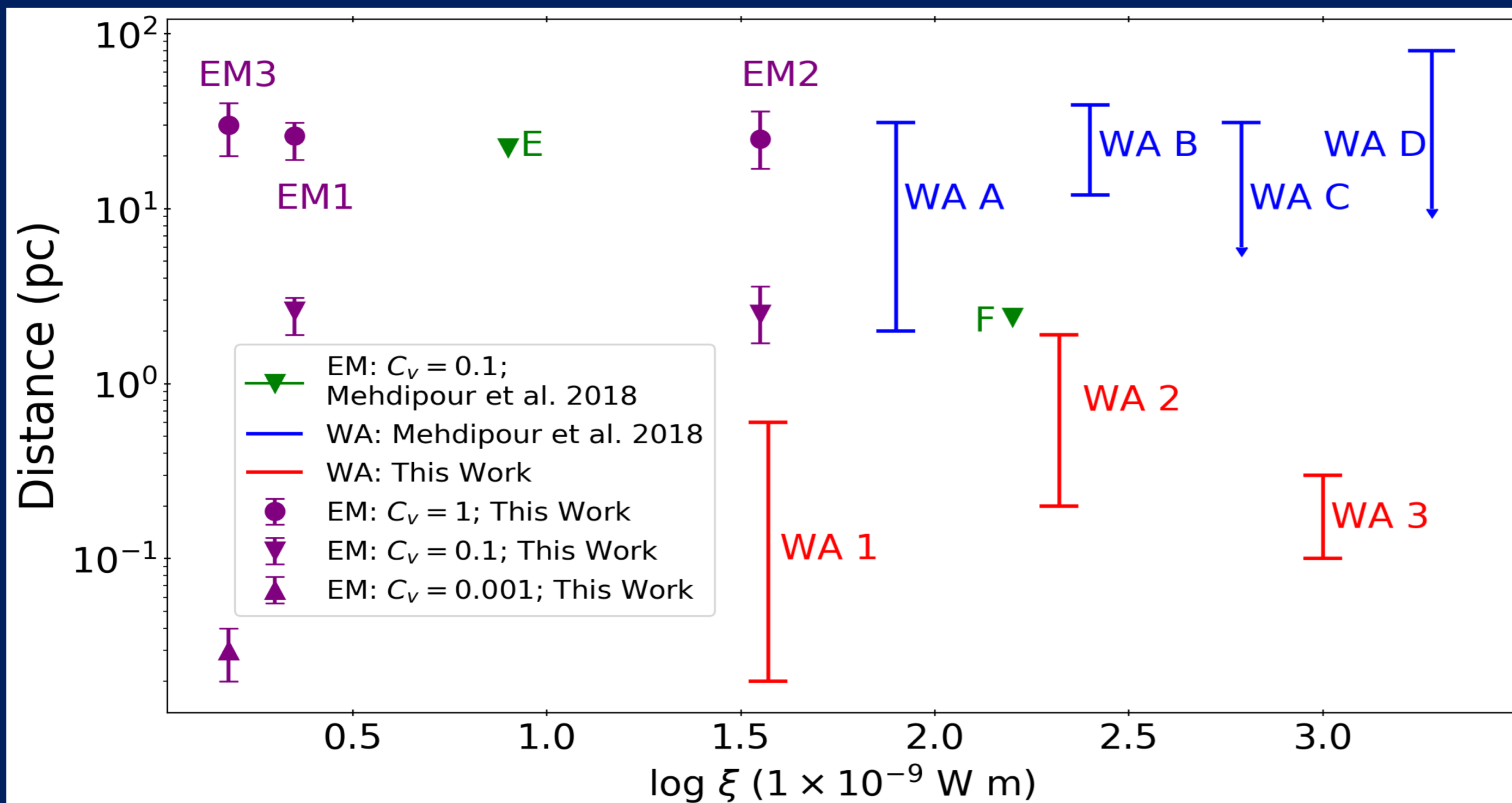
- We find three WA components and three emission components (two narrow and one broad) within the nucleus of NGC 7469.
- We characterise the emission features in NGC 7469 for the first time, deriving estimates for the minimum distances of the ELR from the central engine using Eq. 1, below.
  - ❖  $r \gtrsim 2.5$  pc for the two narrow line components (EM1 & EM2).
    - Adopt an extended emission region;
    - Assume  $C_v = 0.1$  (see third column in Table 1).
  - ❖ This places the ELR further out from the black hole than the WA (Figure 1).
- For the broad emission line region (EM3) the distance is found at either 0.03 pc (assuming  $C_v = 0.001$ ) using the ionisation parameter ( $\xi$ ), or 0.004 pc if the outflow velocity ( $v = -4460$  km s<sup>-1</sup>) is used.



**Figure 1:** Comparing the distances between the WAs (green) and the ELRs (orange) with respect to the central black hole.

- From variability arguments [1, 2], on the other hand, the distance of the WA is  $\sim 10$  times larger than EM1 and EM2 (Figure 2).
- Therefore,  $0.1 < C_v < 1$  will place the narrow ELR at a similar distance to that derived from variability arguments for the WA components.

$$r_{\text{min}} = \frac{L_{\text{ion}} C_v}{N_{\text{H}} \xi} \quad (\text{Eq. 1})$$



**Figure 2:** Comparing the distances of the ELR (purple) to the WA distances (red) in this work, and from variability arguments (blue) [1]. It shows that if  $0.1 < C_v < 1$ , then the ELR is at a similar distance as the WA.

Emission Comp.	R (pc)	R (pc)
EM1	$26^{+3}_{-7}$	$2.62^{+0.31}_{-0.73}$
EM2	$25^{+11}_{-8}$	$2.52^{+1.05}_{-0.81}$
EM3	$30 \pm 10$	$0.03 \pm 0.01$

**Table 1:** Comparing the distances of the ELR in NGC 7469 if we use  $C_v = 1$  (left) or  $C_v = 0.1$  (right).

Model	NGC 5548		
	N1 (pc)	N2 (pc)	B1 (pc)
D	13	142	-
T	19	93	0.09
Date	NGC 3783		
2000/01	0.01	1.94	0.01
11 Dec 2016	0.03	10.4	0.01
21 Dec 2016	0.04	15.6	0.01

**Table 2:** Comparing the ELR distances within NGC 5548 (top) [3] and NGC 3783 (bottom) [4].

- We compare the ELR of NGC 7469 with those within NGC 5548 [3] and NGC 3783 [4], calculating the lower ELR distance limits within each AGN using Eq. 1 (see Table 2).
- The ELR distances in NGC 5548 are comparable to previous analysis of the NLR ( $r = 13.9$  pc) [5].
- The narrow (N1) and broad (B1) ELR distances in NGC 3783 are comparable to each other (Table 2) due to the large ionisation parameter of N1.
  - ❖ We overcome this problem by allowing  $0.1 < C_v < 1$  for the narrow ELRs.
  - ❖ Alternatively, the broad emission component may have  $C_v < 0.001$ .

## Conclusions

- Minimum distances of the narrow ELR within NGC 7469 have been estimated at  $r \gtrsim 2.5$  pc (Figure 1).
  - ❖ For the ELR to be further away from the black hole than the WA,  $C_v = 0.1$  (third column of Table 1).
- However, from variability arguments, the WA distance is  $\sim 10$  times larger than ELR distance.
  - ❖ Therefore, we require a range of  $0.1 < C_v < 1$  to overcome this inconsistency (Figure 2).
- If the broad ELR has  $C_v < 0.001$ , then the ionisation and kinematic distance measurements for EM3 are consistent within NGC 7469.
- Large uncertainties in  $C_v$  mean further work is required to investigate this parameter.

## References

- [1] Mehdipour et al. 2018, A&A, 615, A72
- [2] Peretz et al. 2017, A&A, 609, A35
- [3] Mao et al. 2018, A&A, 612, A18
- [4] Mao et al. 2019, A&A, 621, A99
- [5] Whewell et al. 2015, A&A, 595, A85