

Ultra-fast outflow responses in highly accreting supermassive black holes

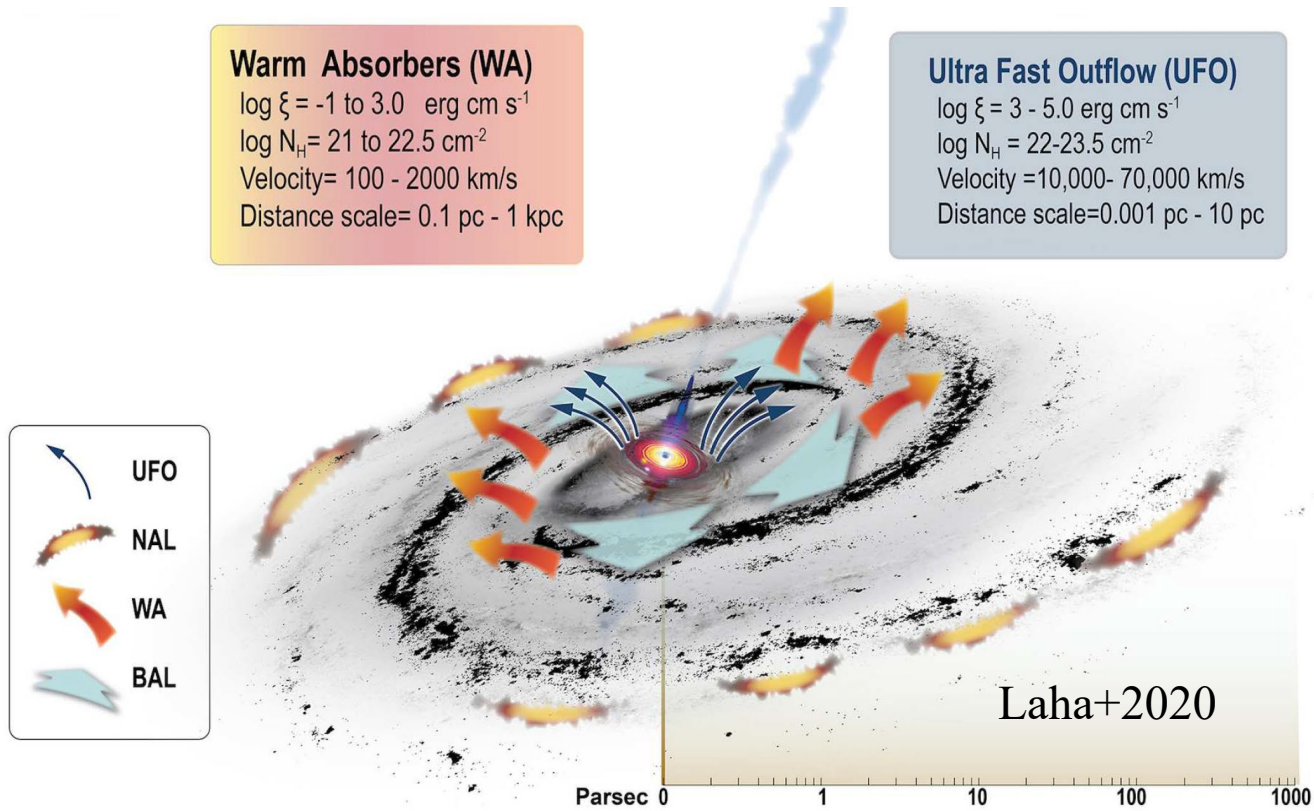
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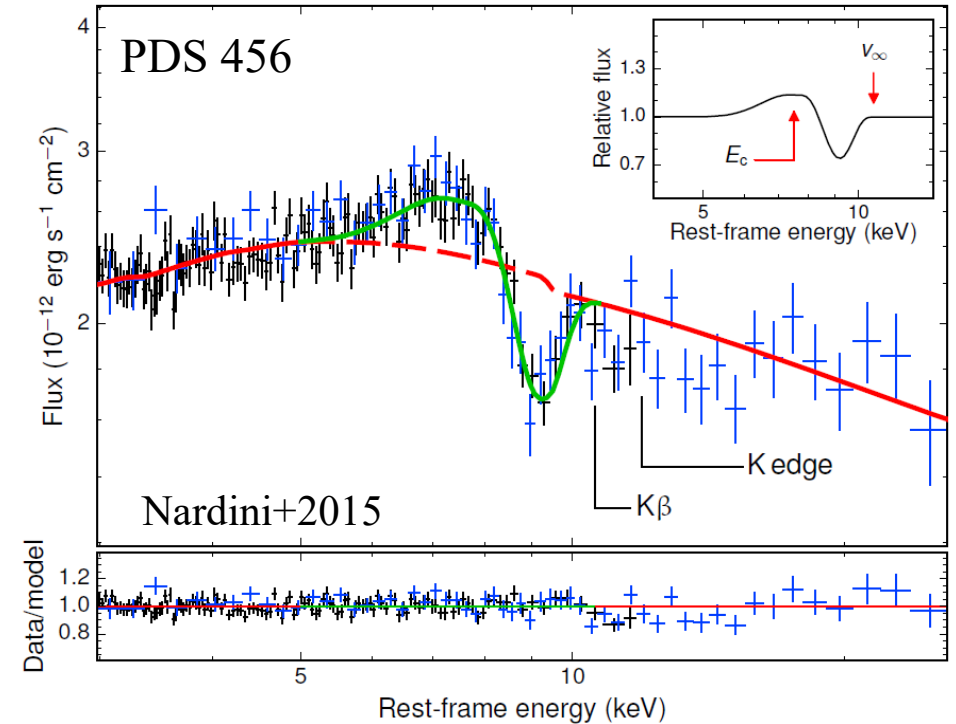
2nd Aug 2023 @ HRXS workshop

Supported by ESA archival research visitor programme

Ultra-fast outflows (UFO) in AGN



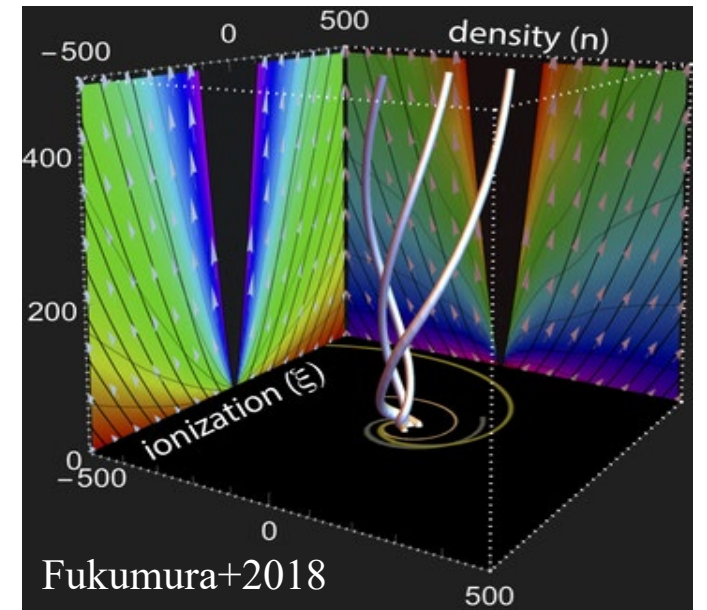
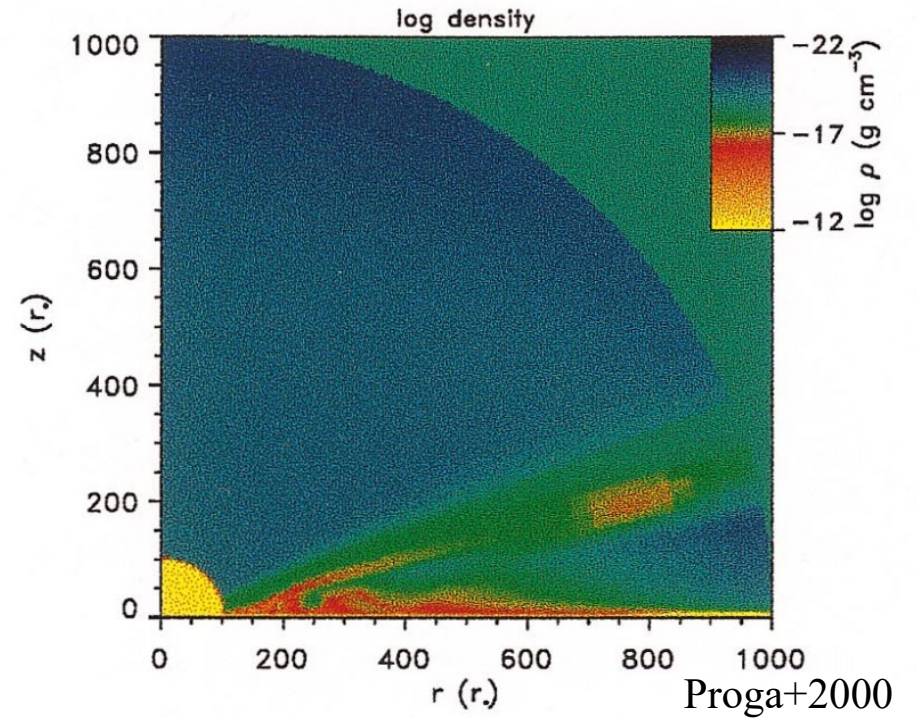
The highly-ionized and extremely fast gas carries up a huge amount of kinetic energy, which might be sufficient ($L_w > 0.5\% L_{Edd}$) to affect the host galaxy.



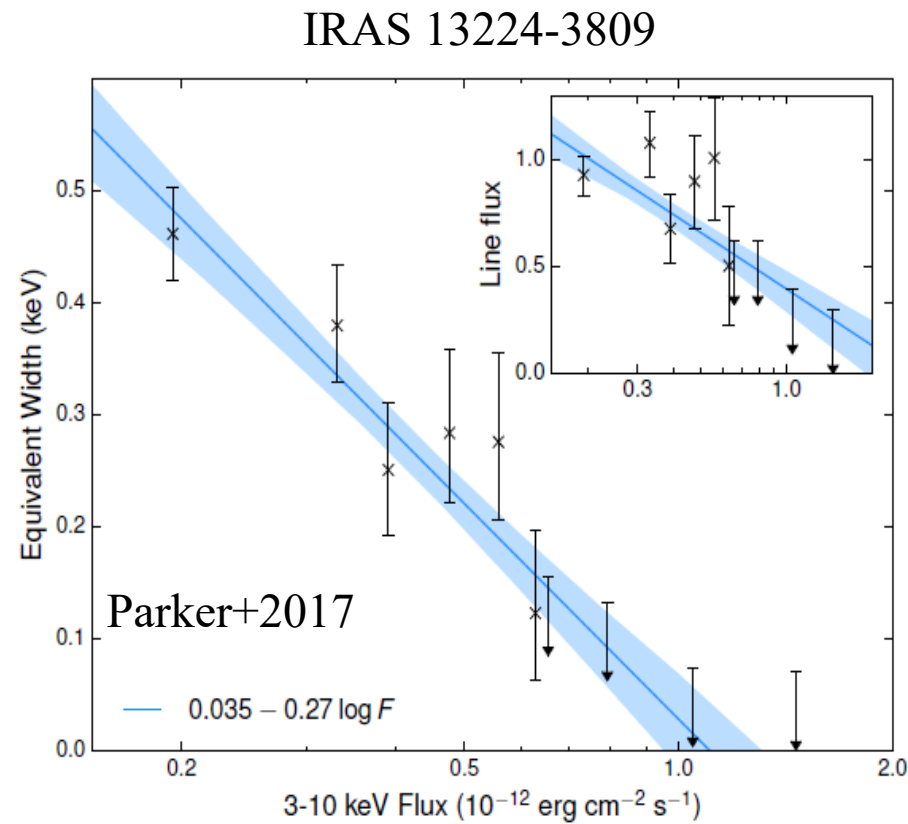
UFO detected with strongly blueshifted absorption features (along our LOS)

UFO launching mechanism

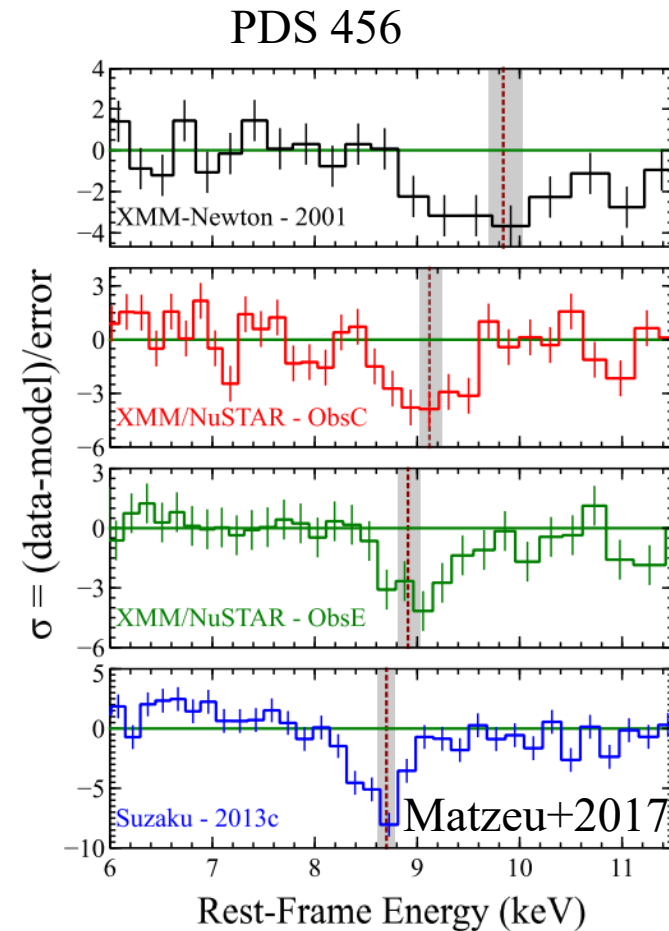
- Radiation-driven outflow
 - Winds accelerated by the strong radiation pressure
 - Naturally expected in highly accreting systems
- Magnetically-driven outflow
 - Wind launched along magnetic field lines



Evidence for radiation-driven outflow in high-accretion AGN

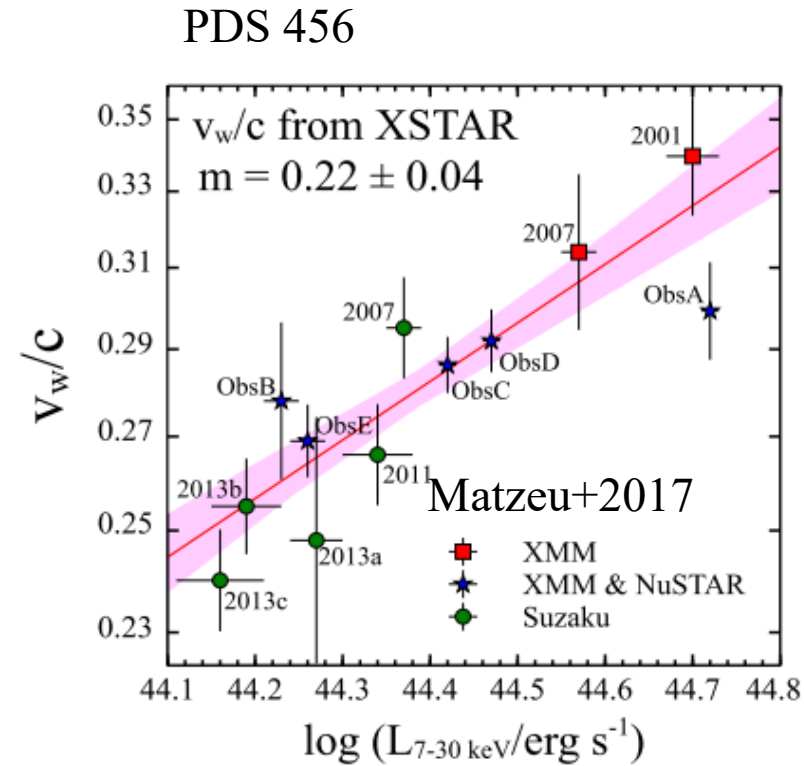
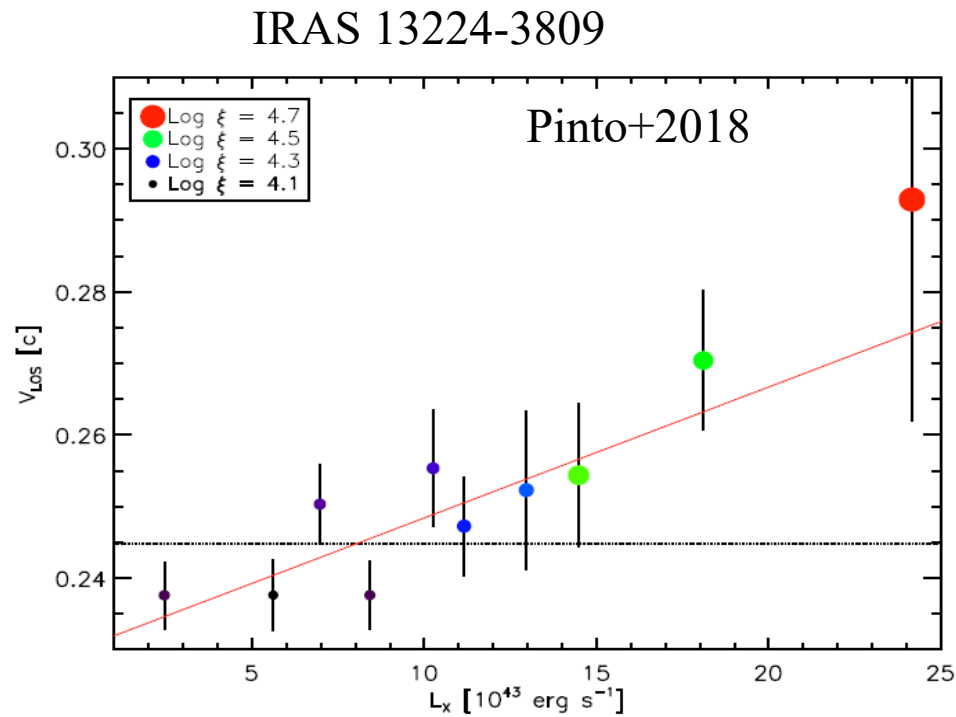


- The EW and flux of Fe XXV/XXVI absorption decrease with X-ray flux
→ Over-ionized by strong X-ray luminosity



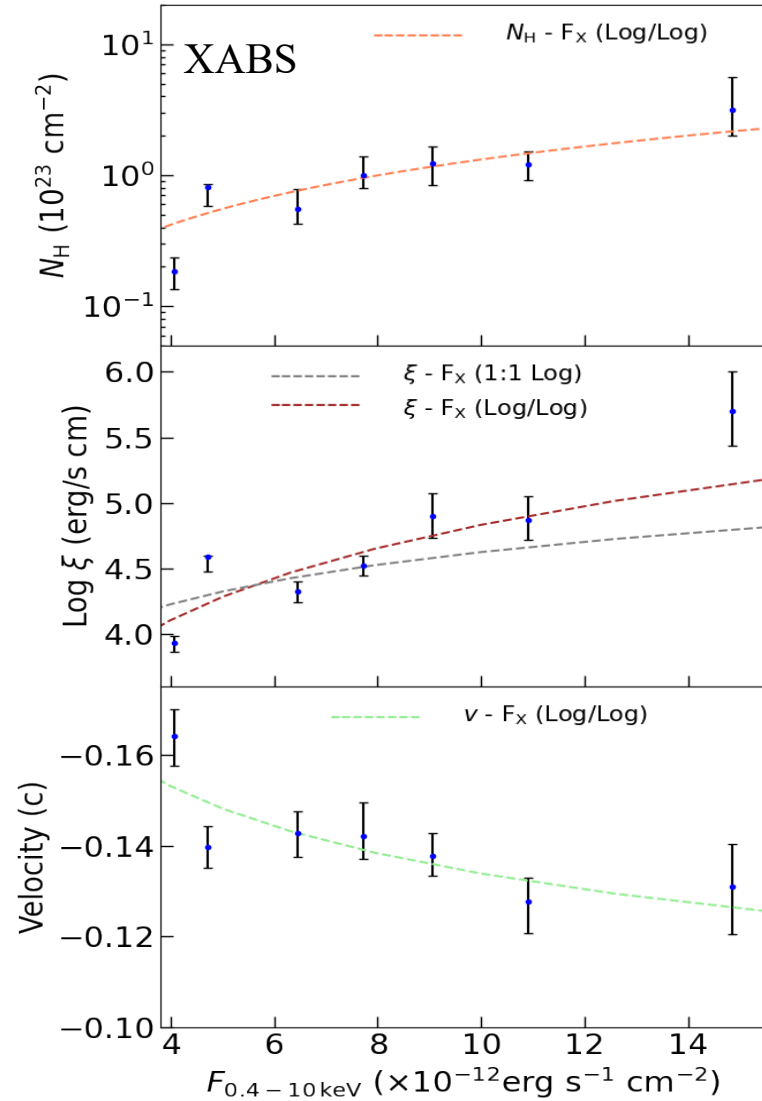
- The blueshift of UFO absorption lines increases with the flux

Evidence for radiation-driven outflow in high-accretion AGN



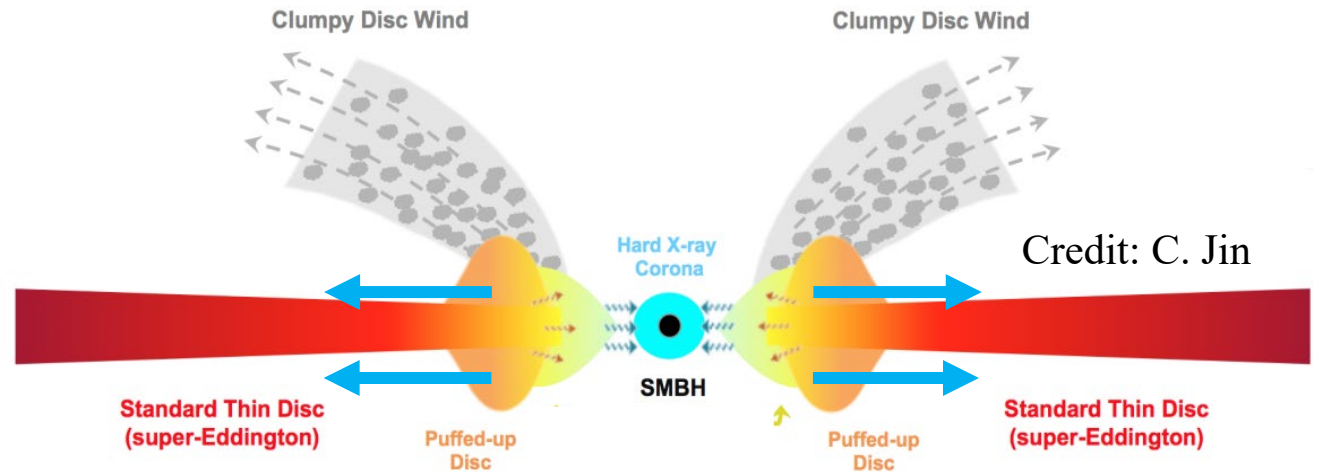
- UFO is accelerated by strong radiation field in high-accretion AGN

The peculiar case of 1H 0707-495 (Xu+2021b)



Possible Explanations:

1. MHD driven wind (Fukumura+2018) predicts a decreasing velocity
2. Over-ionized gas experiences lower radiation driven force.
3. Super Eddington radiation ($L_{\text{bol}}/L_{\text{Edd}} \sim 0.7 - 20$) extends the launch radius outwards.



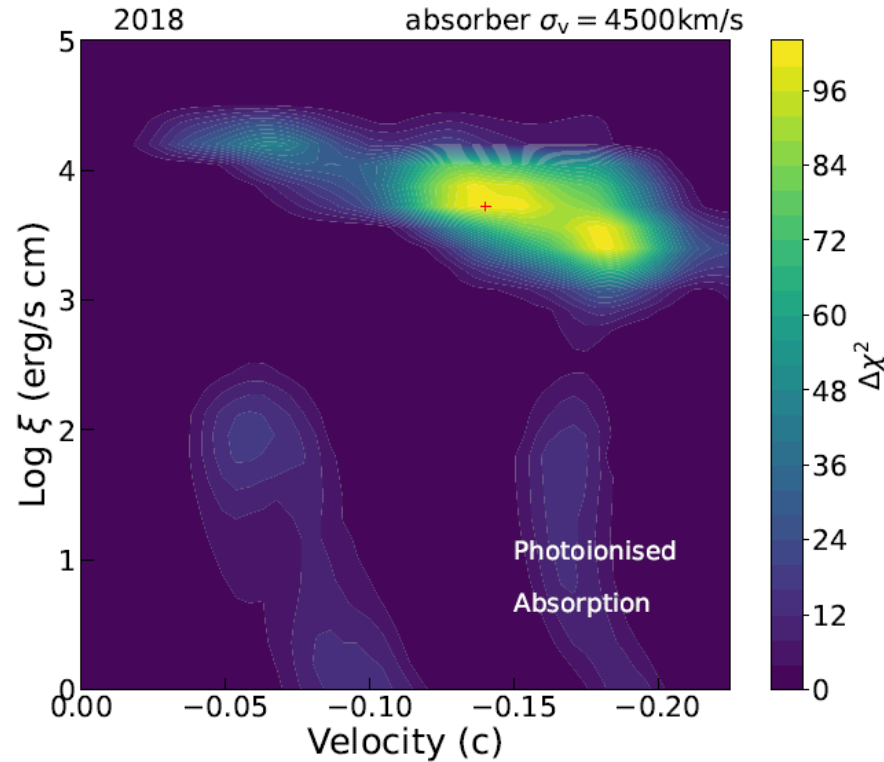
Sample Selection Criteria for archival XMM-Newton/RGS datasets

- No heavy obscuration (Type I AGN): $N_H < 10^{22} \text{ cm}^2$
- Enough counts (long exposure or bright enough): $> 50,000$ Counts in RGS spectrum
- Strong detection significance of UFO: $> 3\sigma$, i. e., $\Delta C - stat > 16$

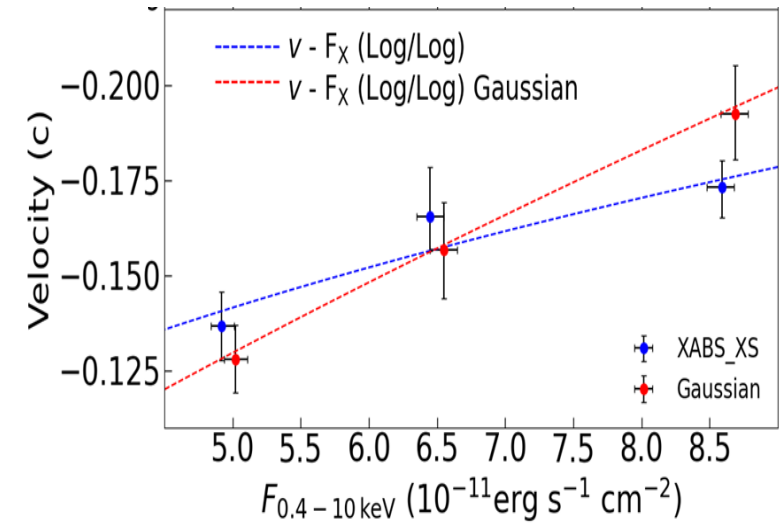
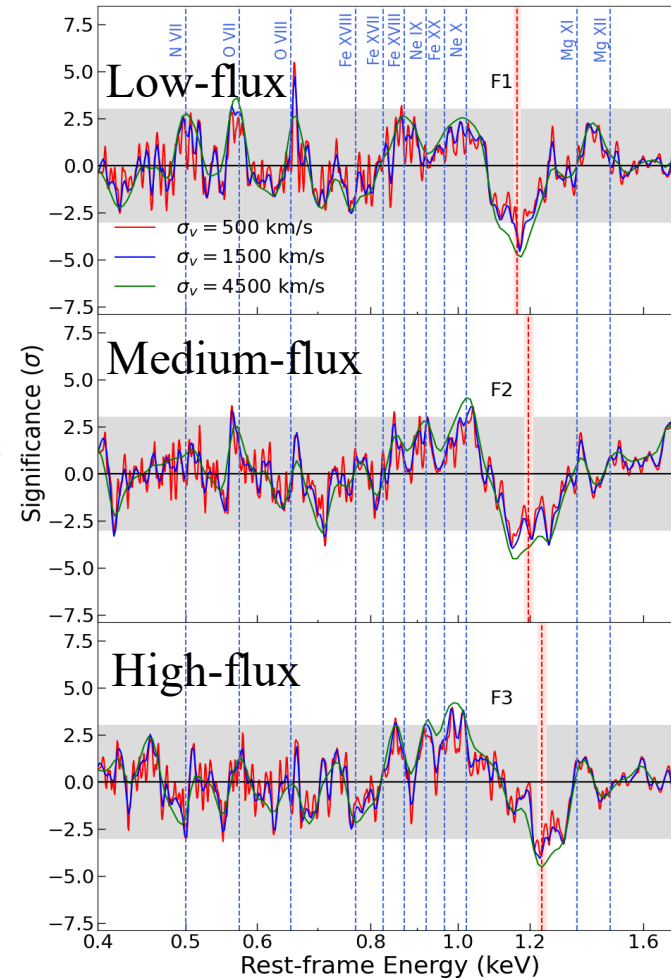
Benchmark: UFO response in Mrk 1044 (Xu+2023)

Gaussian line scan over the flux-resolved spectra

Grid search of the photoionization model

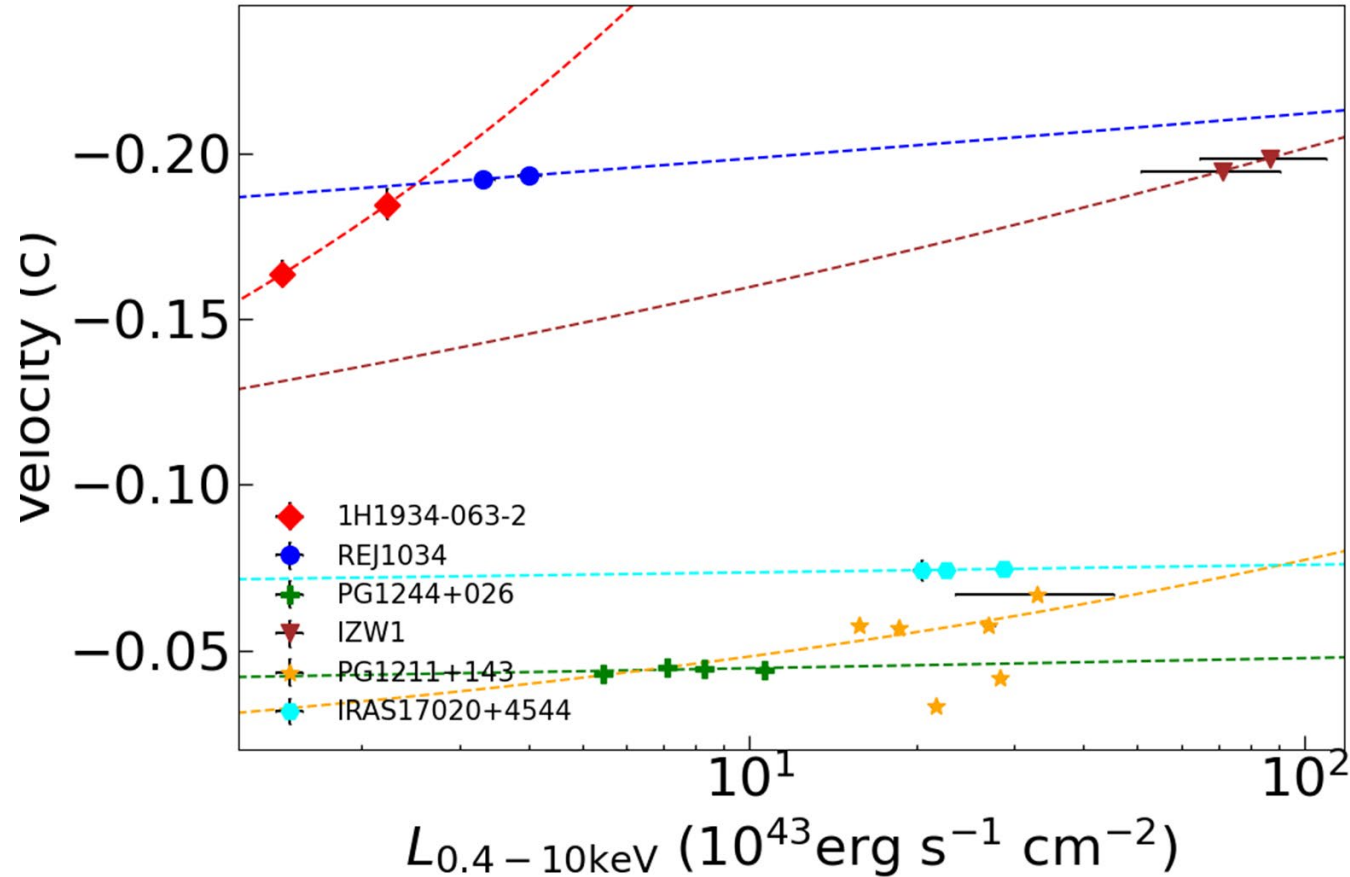


UFO is strongly detected in Mrk 1044 ($\Delta\chi^2 > 96$).



UFO in Mrk 1044 is accelerated by the radiation pressure.

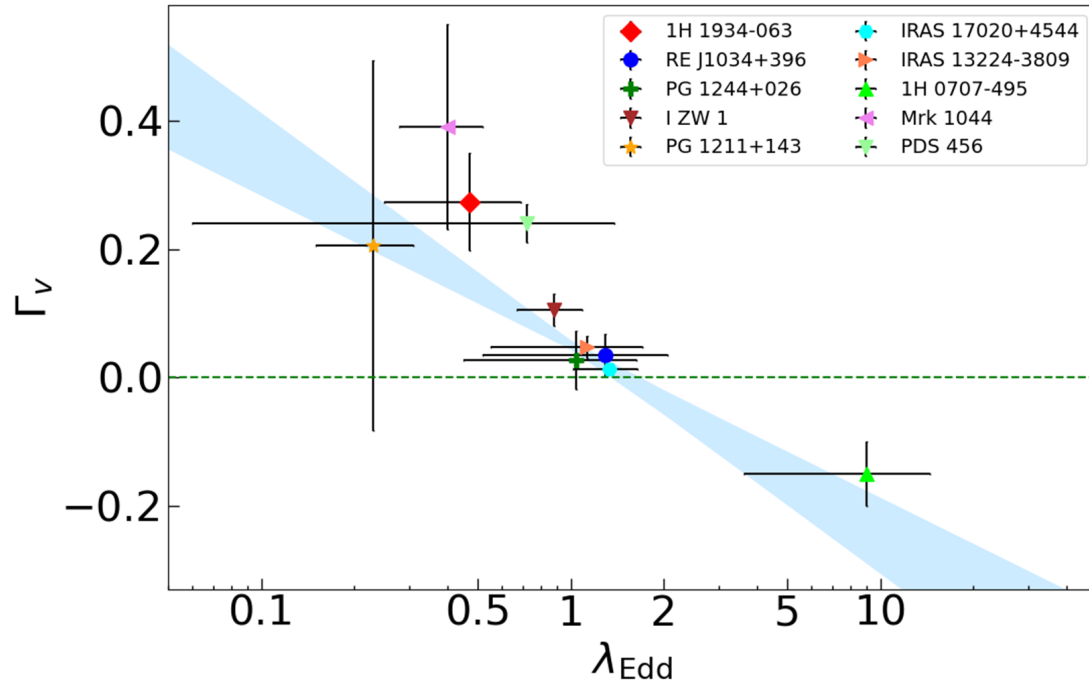
UFO response in the sample (Xu in prep.)



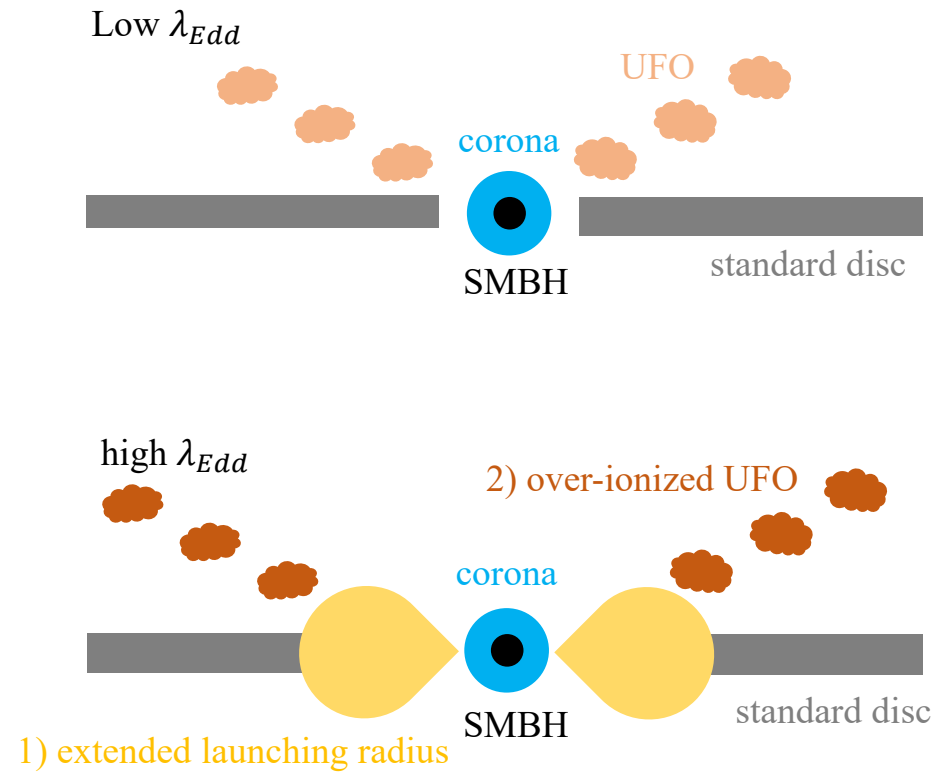
Report undiscovered UFOs in two AGN
(RE J1034+396 and PG 1244+026)

UFOs in our sample are either accelerated by the radiation pressure or unchanged probably due to the response time delay of the momentum to the source variation.

UFO response in the sample (Xu in prep.)

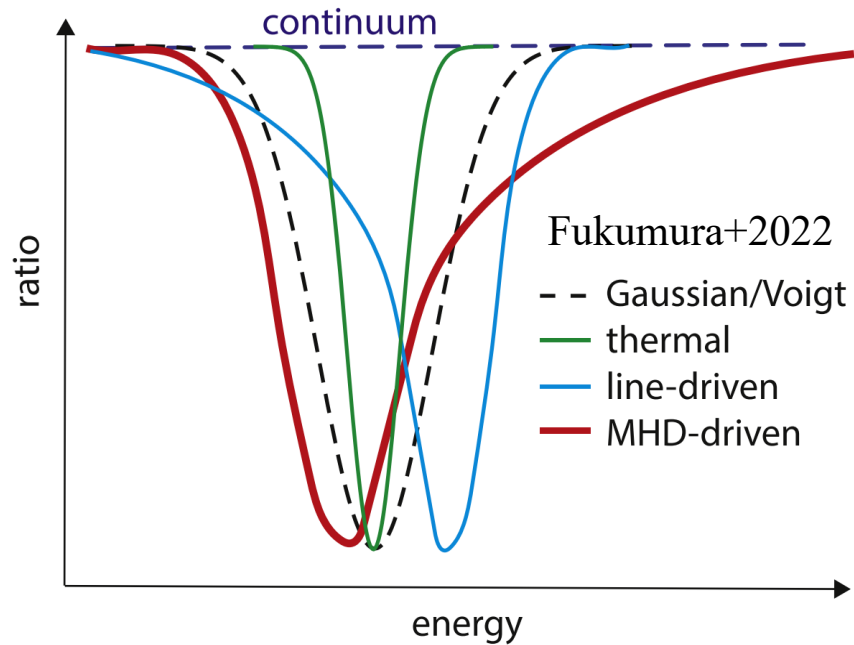


In general, the slope of the velocity (i.e. acceleration) decreases with the Eddington ratio



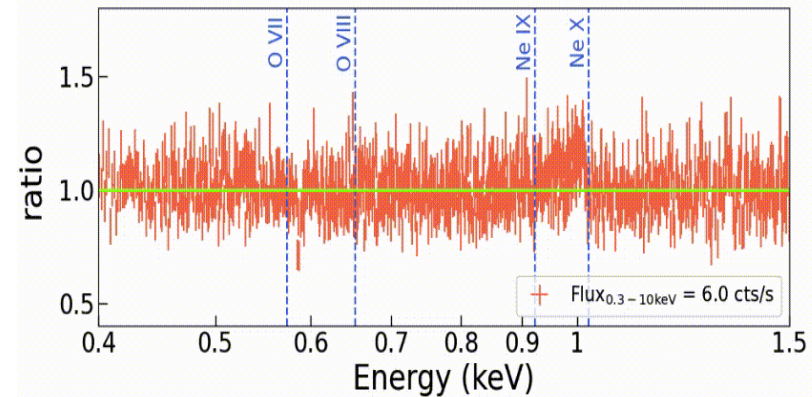
- The UFO acceleration could be reduced
- 1) by the extended launching radius in highly accreting AGN
 - 2) or by the over-ionization of the plasma (lower push)

Future missions: XRISM, Athena and LEM / Arcus



Distinguish the driving mechanism through the line profile

LEM simulation for the UFO response in 1H 1934-063 with 10 ks exposure time



Enable on-time spectral modelling without the need for smoothing the wind features

Conclusion

UFOs in high-accretion AGN are likely driven by radiation pressure, but the acceleration may decrease with the increasing accretion rate.

