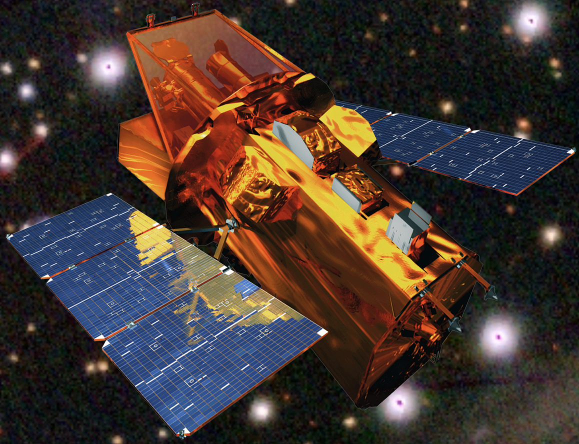
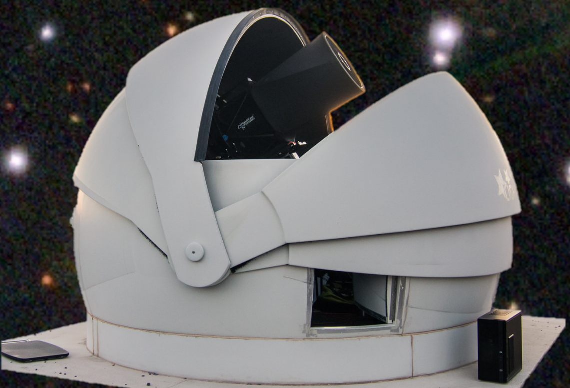


The multifaceted variability of the Seyfert AGN MCG+08-11-11

Daniel Kynoch

Ian M^cHardy, Jonathan Gelbord, Ed Cackett, Keith Horne, Juan Hernández Santisteban, Federico Vincentelli, Hagai Netzer, Michael Fausnaugh

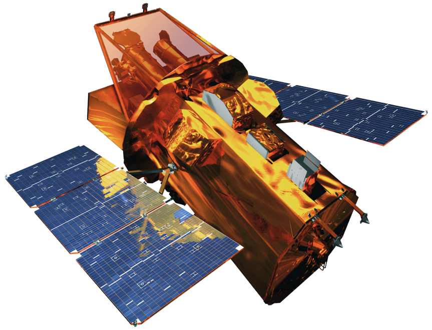


University of Southampton

MCG+08-11-11

- Nearby (z = 0.0205), bright Seyfert galaxy.
- Strong X-ray variability ~months (*Ariel V*; Ward 1977; Treves 1990)
- Intermediate Seyfert / Sy 1.5 (Véron-Cetty & Véron; Cohen 1983).
- Black hole mass ≈ $2.8 \times 10^7\ M_{Sun}$ (Hβ RM: Fausnaugh 2017).
- High accretion rate (≈ 50 % Eddington).

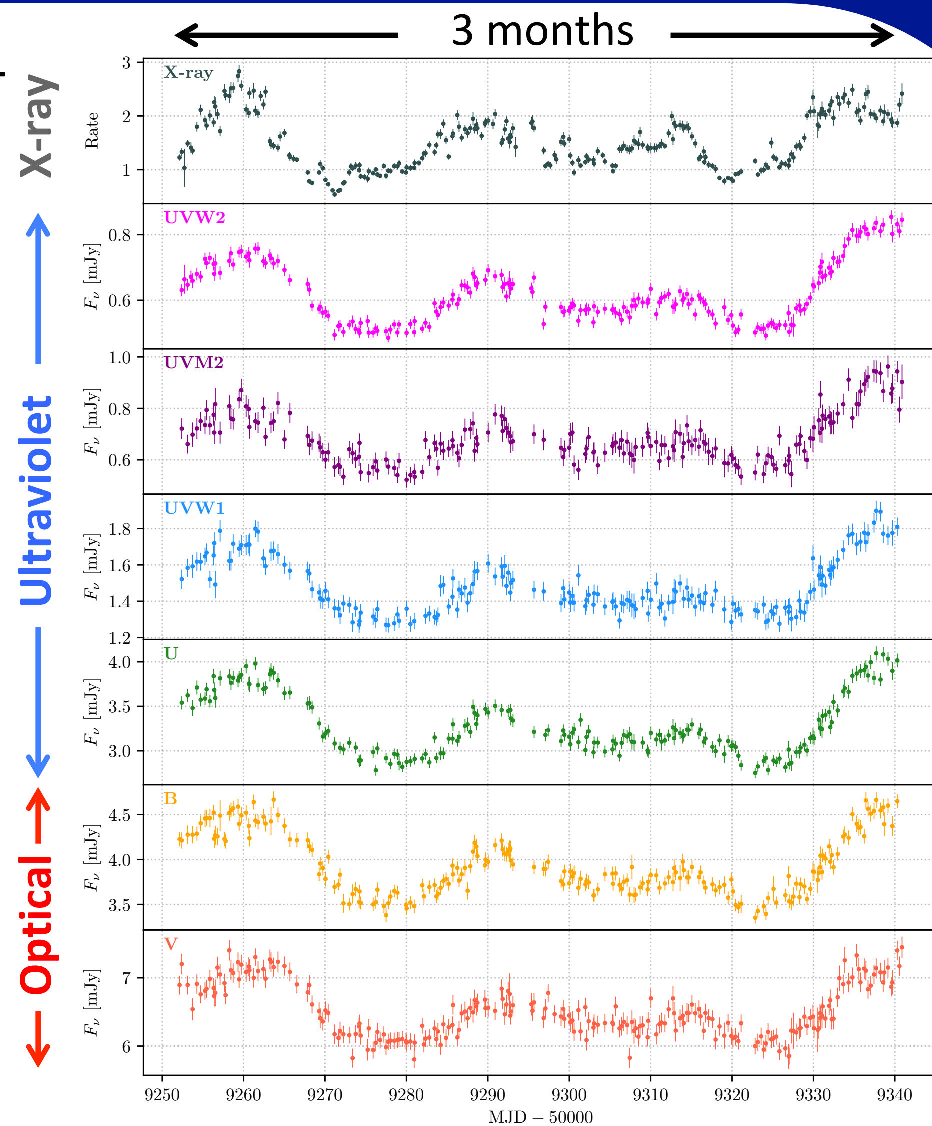
Intensive *Swift* campaign 2021



***Swift* observations:**

- Jonathan Gelbord
- ×3 daily observations over 3 months (February − May 2021)
- XRT + 6 UVOT bands
- Fractional variability:

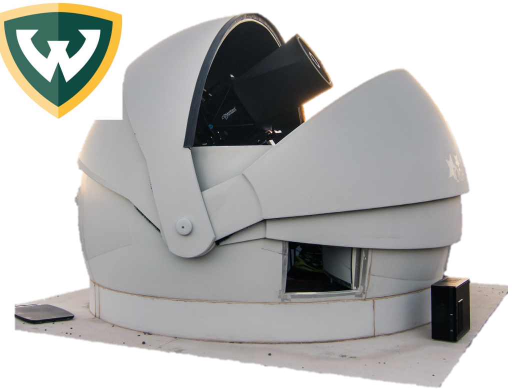
  $F_{var}(X)$ ≈ 32 %
  $F_{var}(UVW2)$ ≈ 14 %
  $F_{var}(V)$ ≈ 5 %

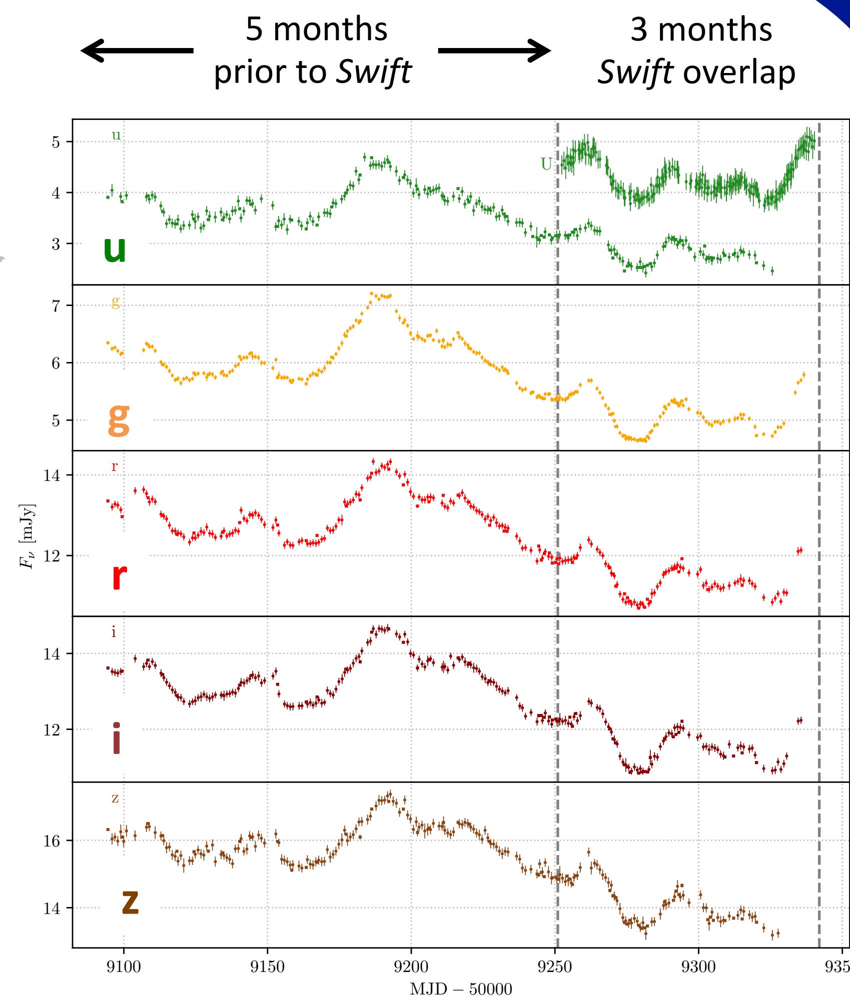


Daniel Kynoch
University of Southampton

The multifaceted variability of the Seyfert AGN MCG+08-11-11

Ground-based campaign 2020-21

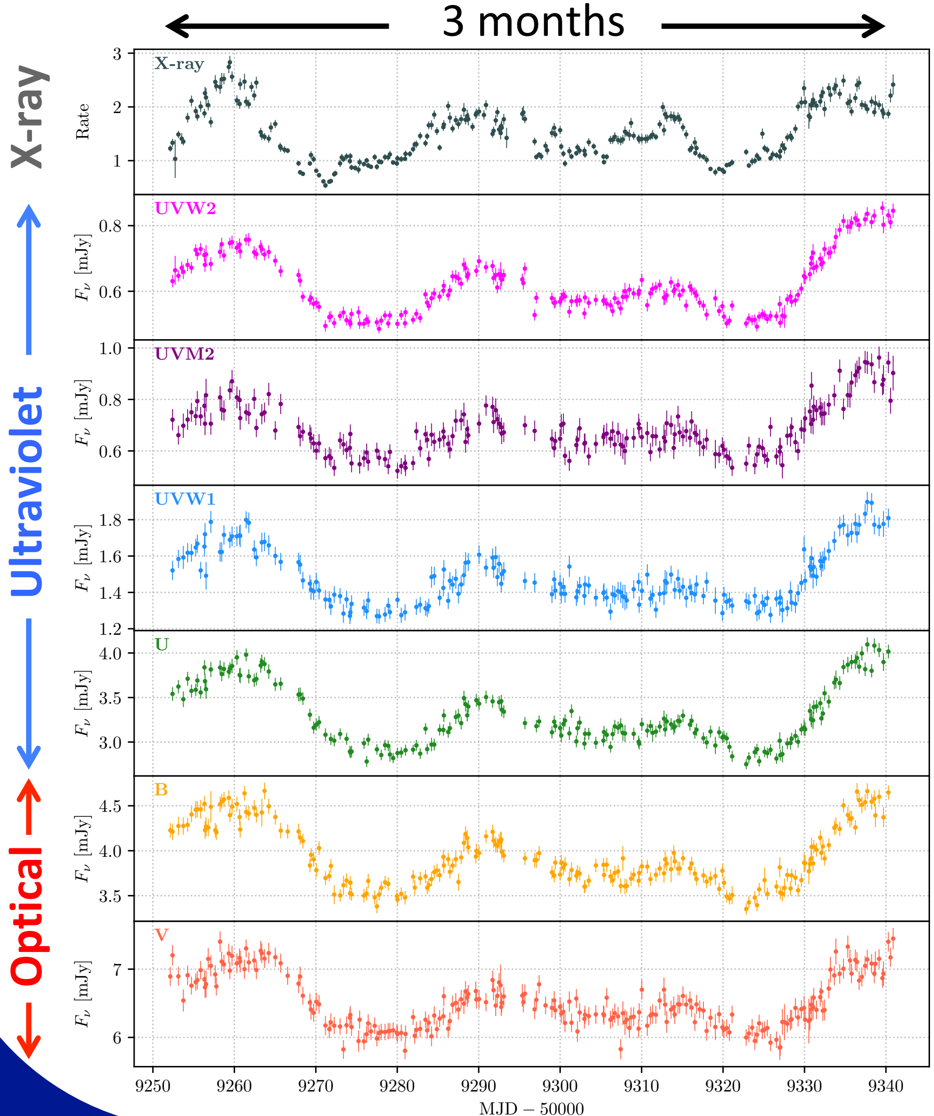


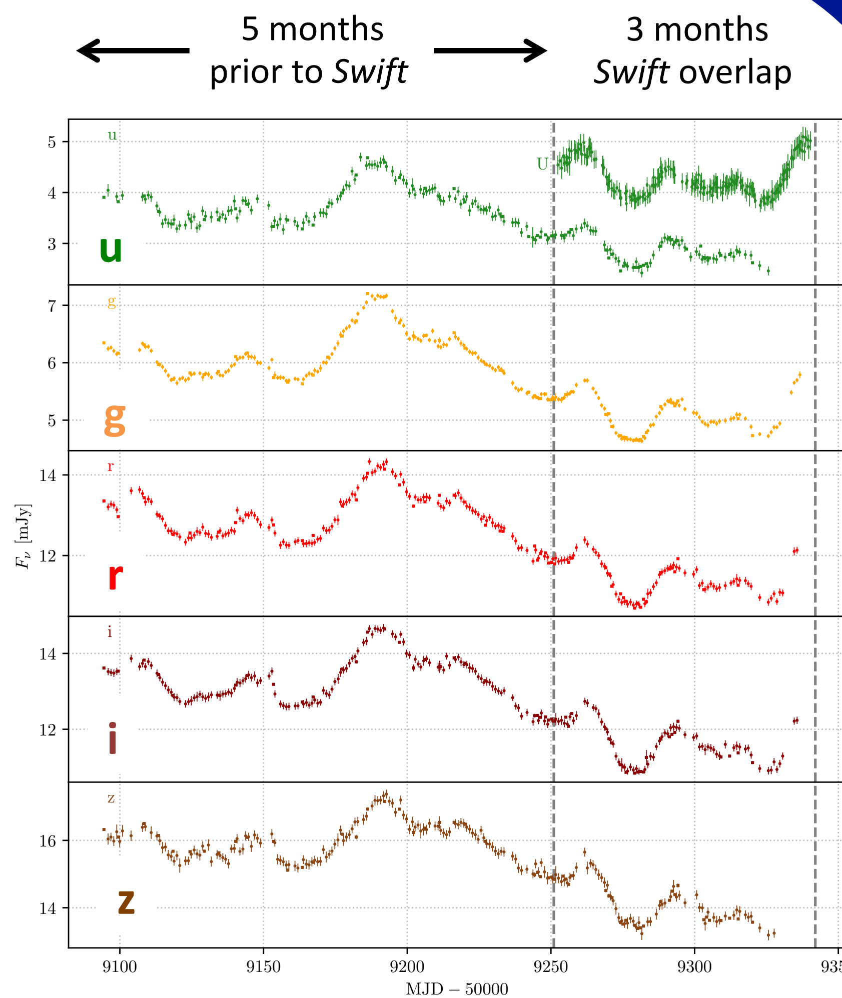


Dan Zowada Memorial Observatory
& Las Cumbres Observatory network:

- Ed Cackett (Zowada)
- K. Horne & J. Hernández Santisteban (LCO)
- Zowada ≈nightly observations over 8 months (September 2020 – April 2021)
- LCO monitoring since January 2020
- 5 SDSS bands: ugriz
- Overlap with intensive *Swift* monitoring

The multifaceted variability of the Seyfert AGN MCG+08-11-11



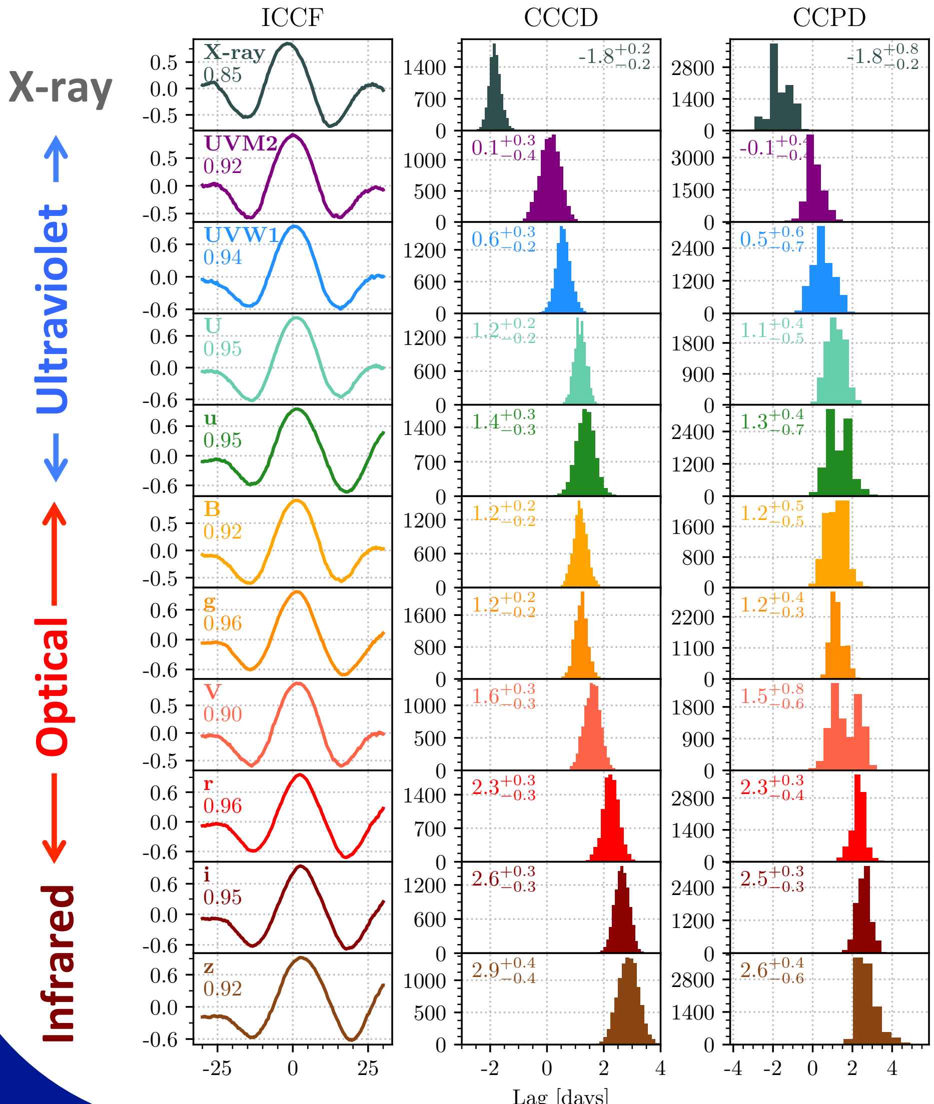


Daniel Kynoch

The Restless Nature of AGN | Napoli | June 2023

University of Southampton

The multifaceted variability of the Seyfert AGN MCG+08-11-11



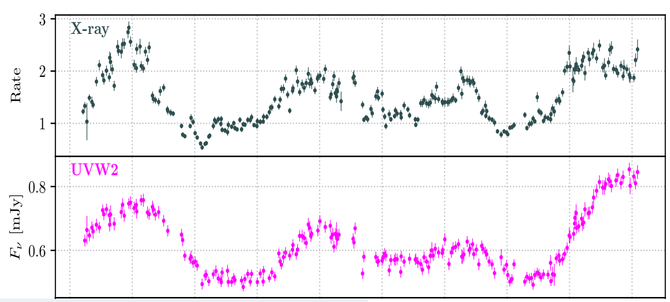
Interpolated cross-correlation functions & lags relative to UVW2 (2083 Å):

- Well-defined cross-correlation functions.
- Strong correlations:
  - X-ray to UVW2 R_{max} = 0.85
  - UVW2 to optical-IR R_{max} > 0.92.
- X-ray lead ≈ 1.8 days.
- Lags increase with wavelength from 0 days (UVM2: 2245 Å) to 2.9 days (*z*: 8922 Å).
- Consistent lags from JAVELIN.

The multifaceted variability of the Seyfert AGN MCG+08-11-11

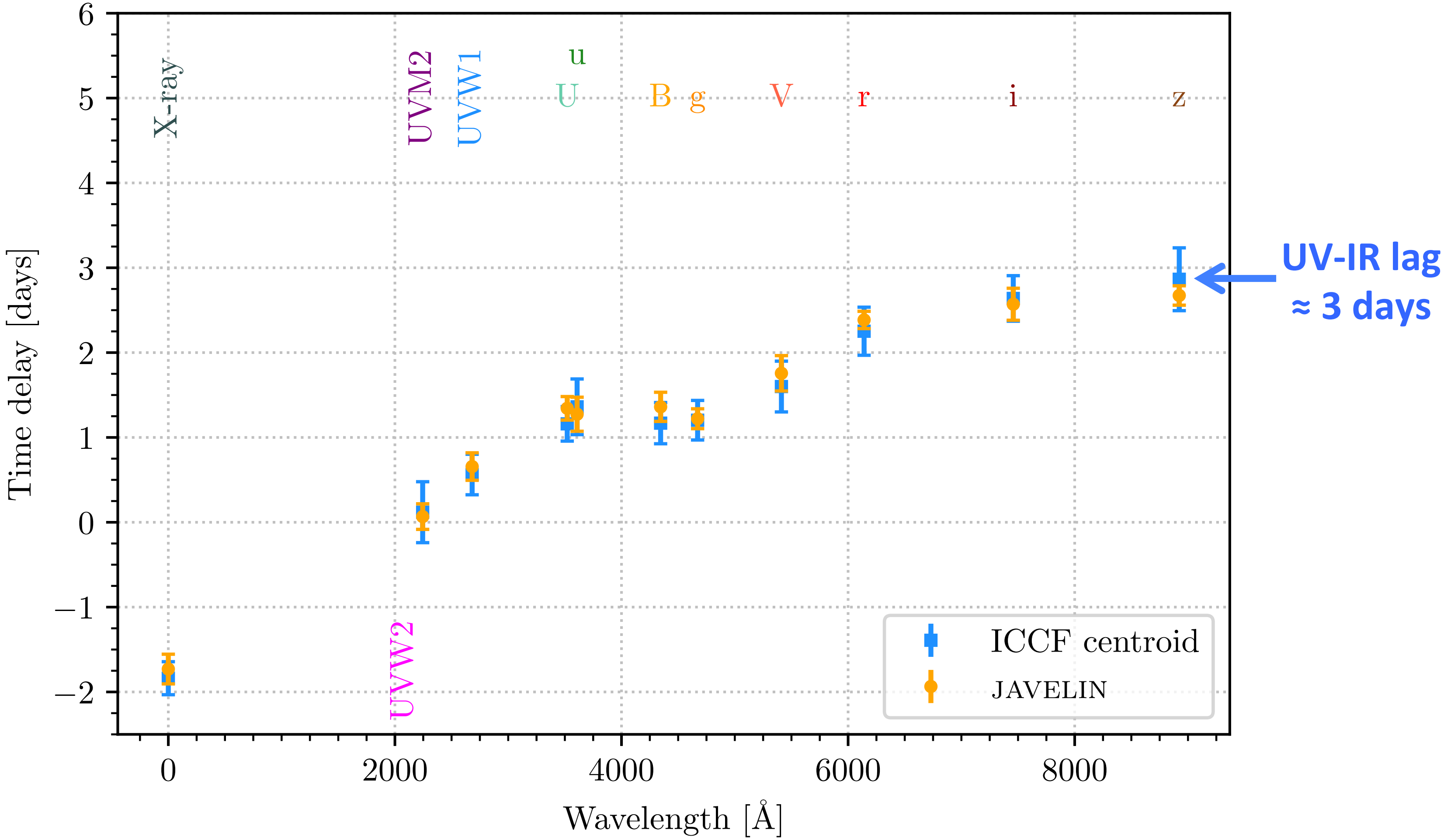
Unusually strong X-ray to UV correlation:

AGN	X-ray-UV R_{max}	UV-opt. R_{max}	Reference
MCG+08-11-11	**0.85**	**0.92 – 0.96**	
Mrk 142	0.54 – 0.74	0.73 – 0.95	Cackett 2020
Mrk 509	0.63 – 0.77	0.97 – 0.99	Edelson 2019
NGC 5548	0.39 – 0.44	0.93 – 0.99	Edelson 2019
NGC 4151	0.36 – 0.68	0.82 – 0.97	Edelson 2019
NGC 4593	0.69 – 0.73	0.70 – 0.97	McHardy 2018; Edelson 2019
Mrk 817	0.33	0.88 – 0.99	Kara 2021; Cackett 2023
Mrk 110	0.29 – 0.65	0.51 – 0.98	Vincentelli 2022
Mrk 335	0.58 – 0.68	0.76 – 0.95	Kara 2023
NGC 7469	0.66	0.72	Kumari 2023



Do *you* know of a stronger X-ray to UV correlation? *Let me know!*

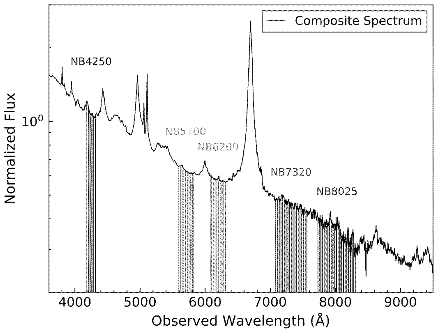
Lag spectrum



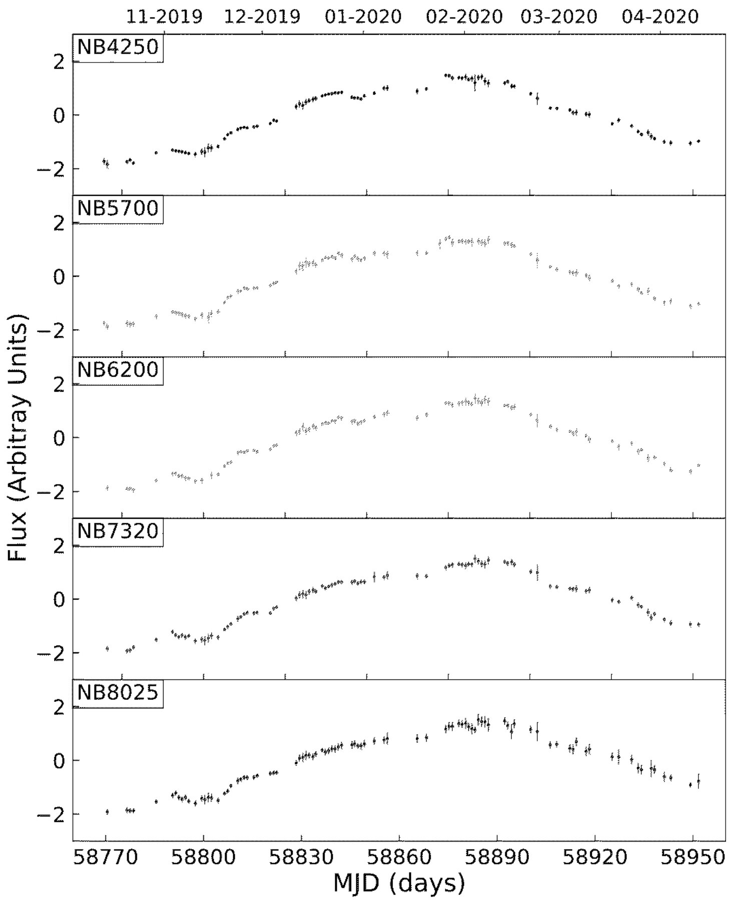
University of Southampton

Earlier optical continuum reverberation (2019-20)

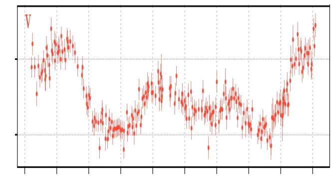
Fian et al. (2023) A&A 672:A132



Narrow filts avoid BLR.
5 bands ≈4250-8025 Å.
Nightly observations over ≈6 months.
'Slow & smooth' variability.

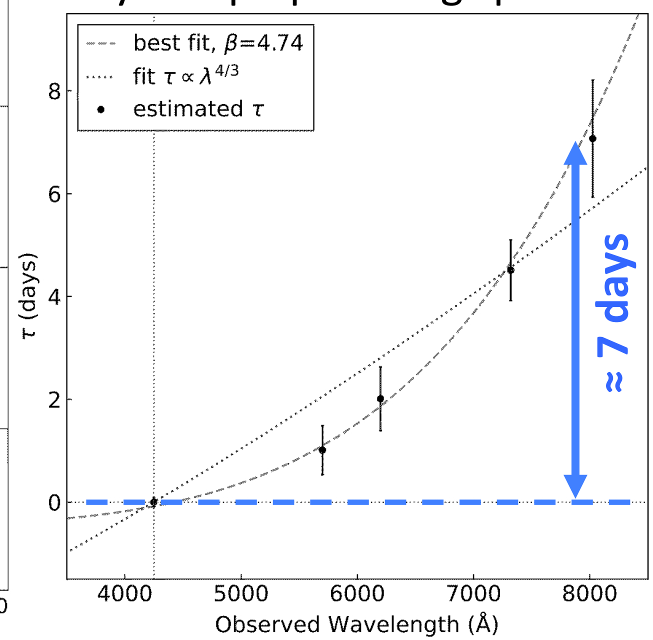


Our data:

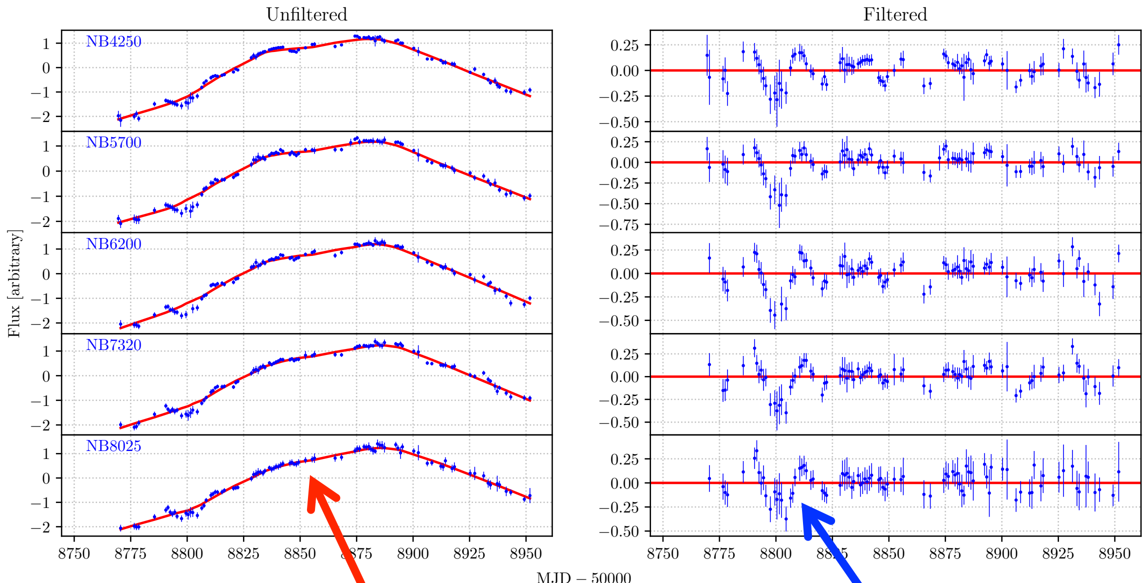


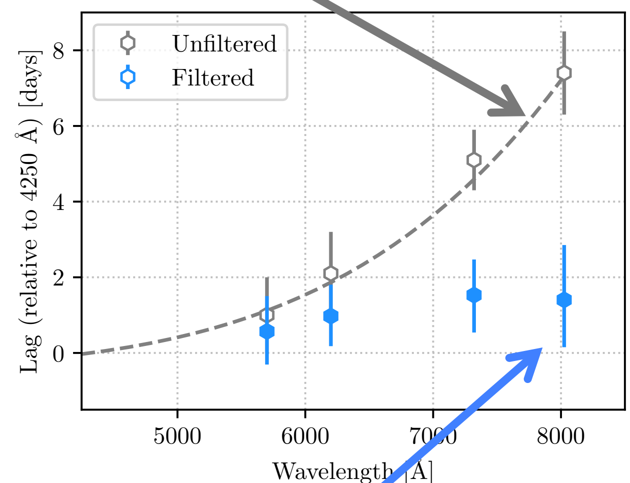
Swift optical lightcurve (3 months)

Very steep optical lag spectrum:



Earlier optical continuum reverberation (2019-20)





unfiltered lightcurves:
long lags

long-term trend
(45 day LOWESS filter)

short-term trend

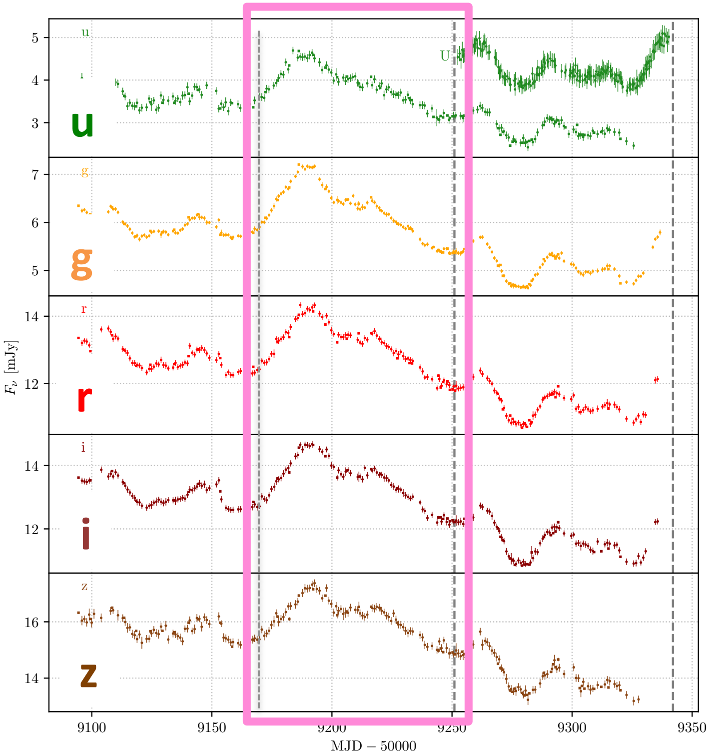
filtered lightcurves:
lags <≈ 2 days
(consistent with *Swift* lags)

Two different components dominate the lags at different times.

- see also F. Vincentelli poster on Mrk 110.

The multifaceted variability of the Seyfert AGN MCG+08-11-11

5 months prior to *Swift* | 3 months *Swift* overlap

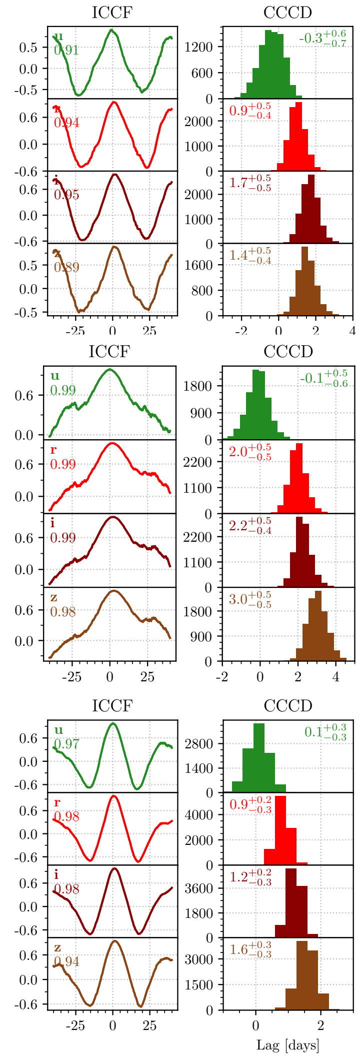


Period 1 | **Period 2** | **Period 3**

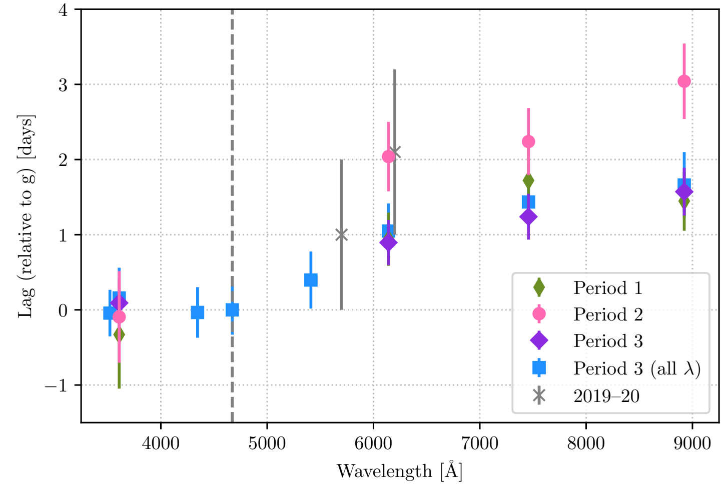
Period 1

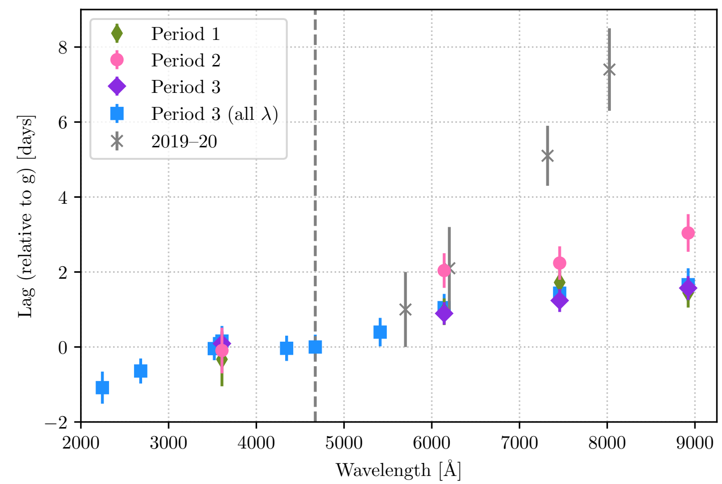
Period 2

Period 3



Longer lags during Period 2:





Daniel Kynoch

The Restless Nature of AGN | Napoli | June 2023

University of Southampton

Modelling the lags (preliminary)

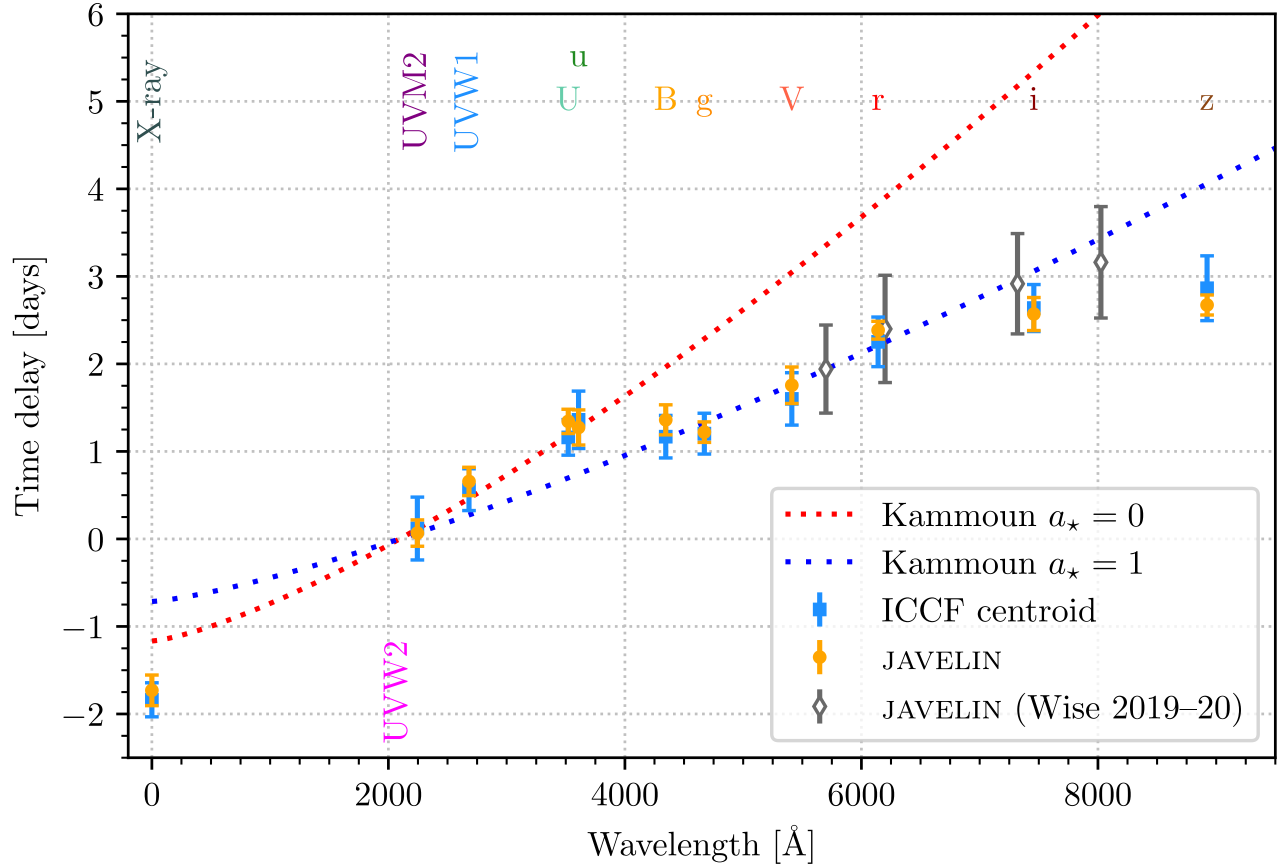
Disc reverberation / GR ray tracing: `kynxilrev` (Dovčiak 2004; Kammoun 2021)

corona height = 10 R_g

logL_X(BAT) = 44.13

logM = 7.5

logL/L_{Edd} = -0.5

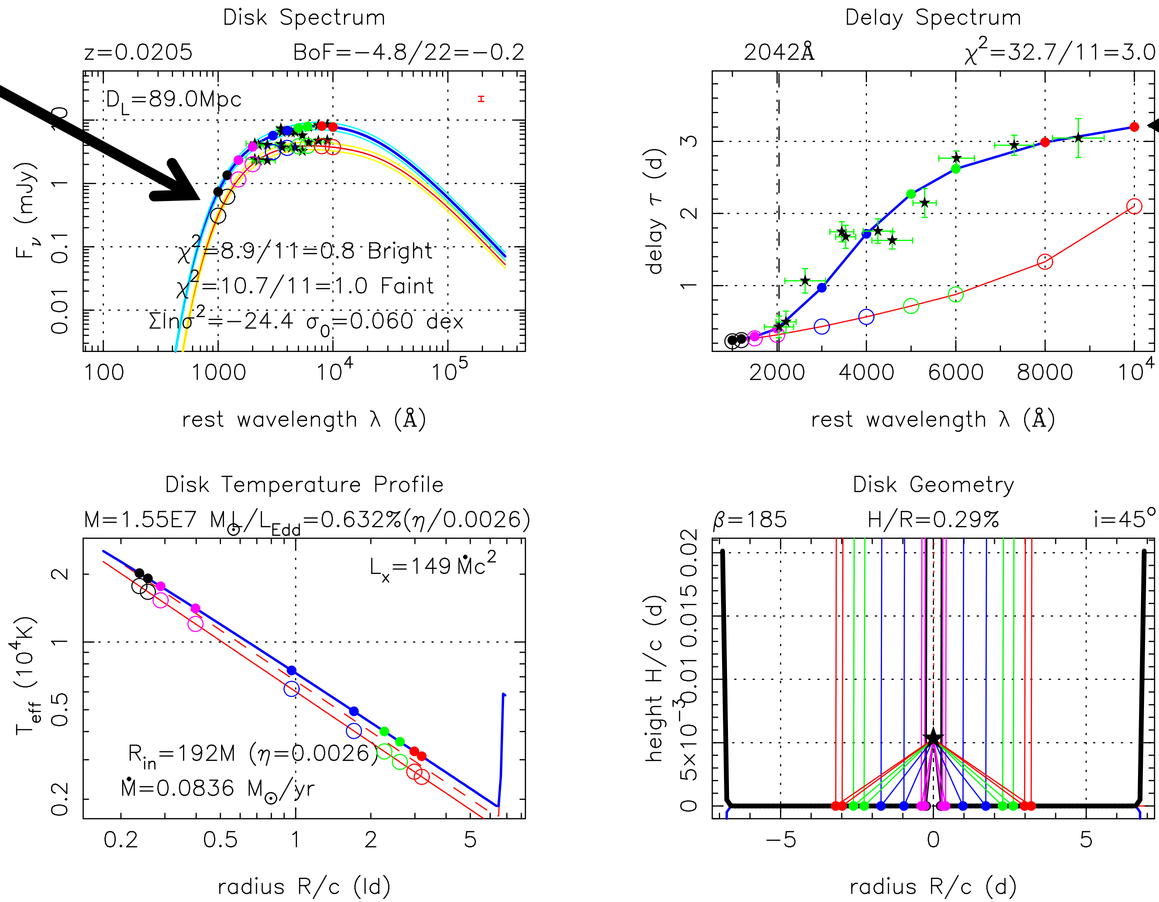


Daniel Kynoch
The Restless Nature of AGN | Napoli | June 2023
University of Southampton

Modelling the lags (preliminary)

‘Bowl’-shaped disc: disc with flared outer edge (Horne)

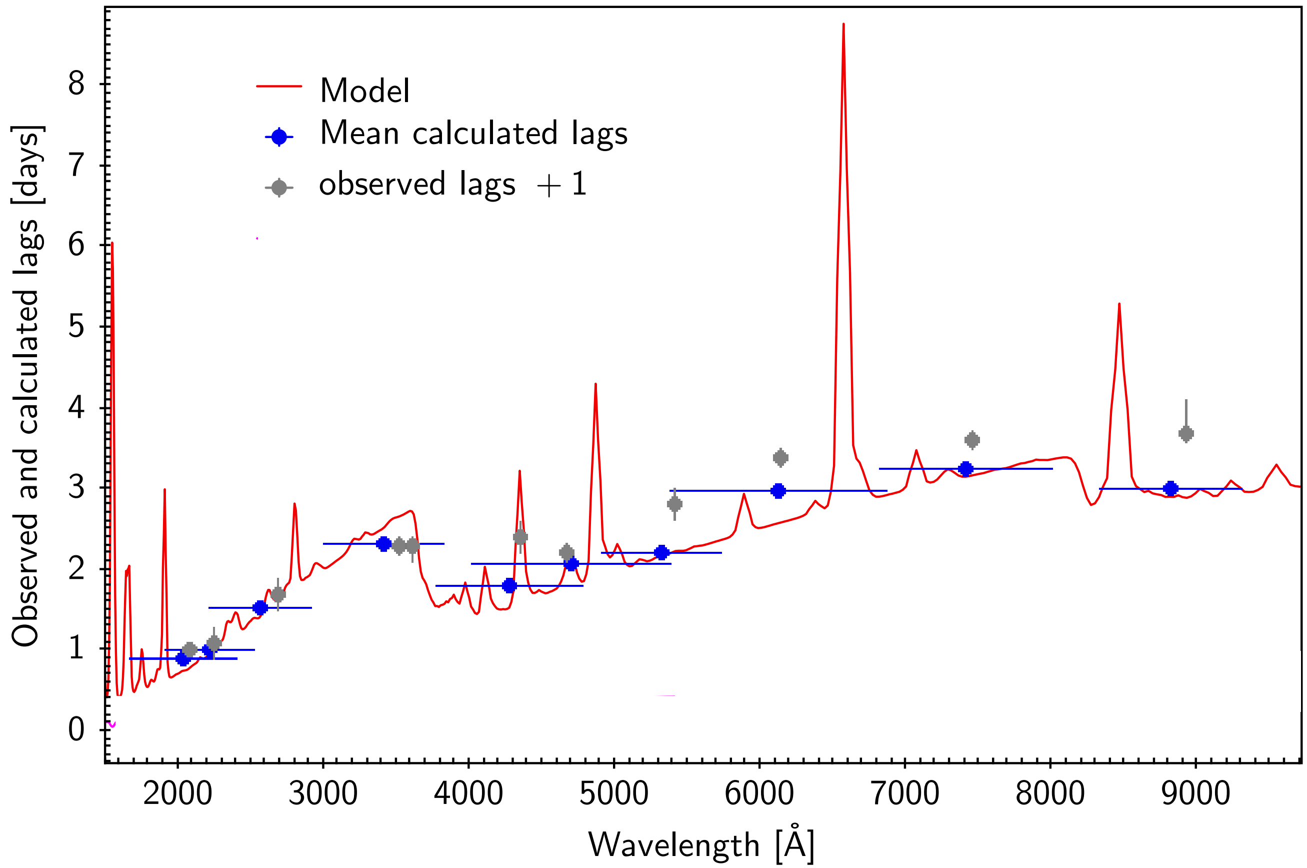
input faint & bright ‘disc’ spectrum from flux-flux analysis



output lag spectrum ≈right scale but smooth curve cannot reproduce observed structure

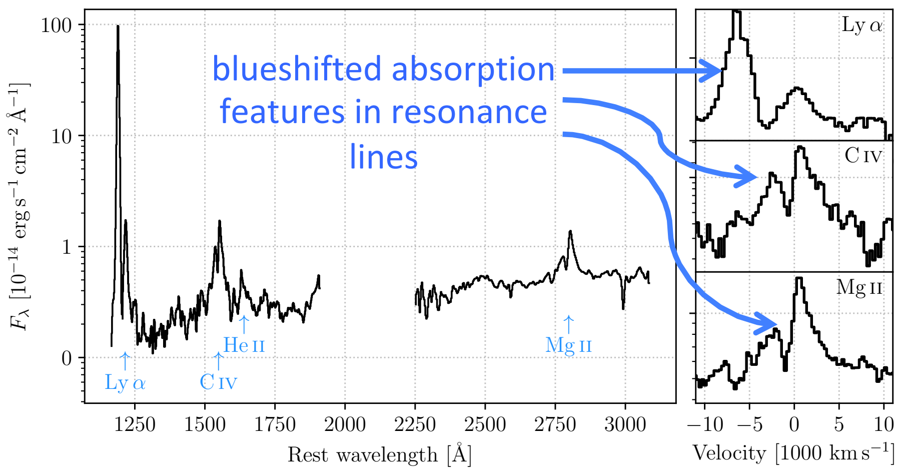
Modelling the lags (preliminary)

Radiation pressure confined clouds (Netzer 2022)

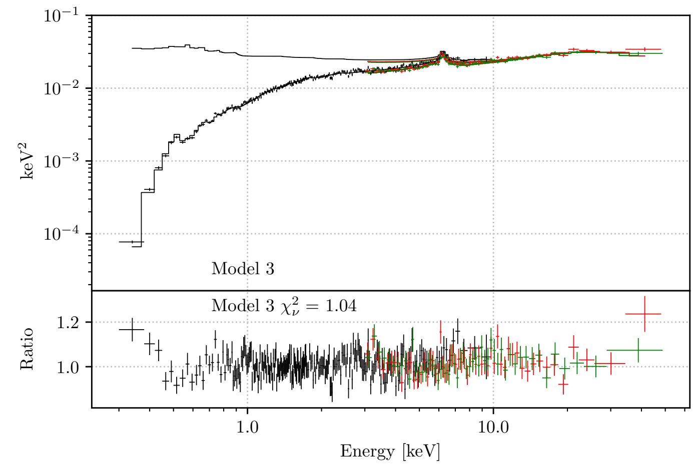


Presence of a wind

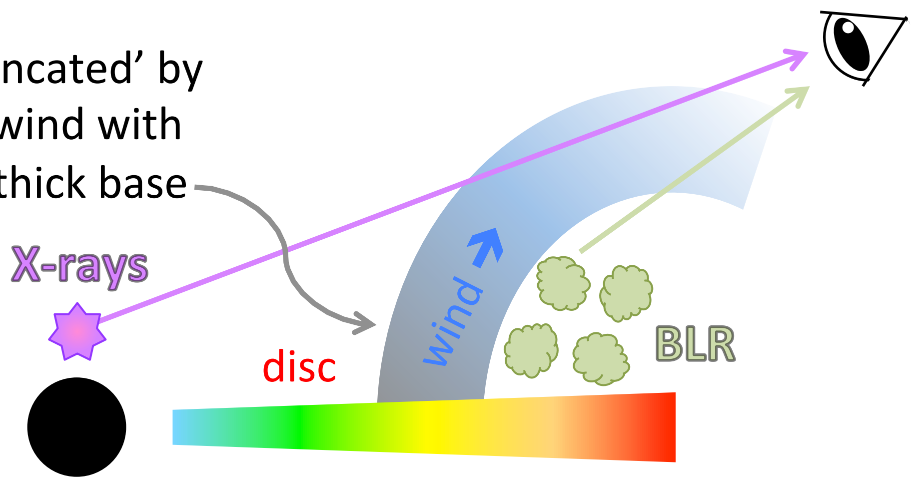
Stacked IUE spectra (1979–86):



Warm abs. in X-ray spectrum:



disc is `truncated' by gaseous wind with optically thick base



Daniel Kynoch
The Restless Nature of AGN | Napoli | June 2023
University of Southampton

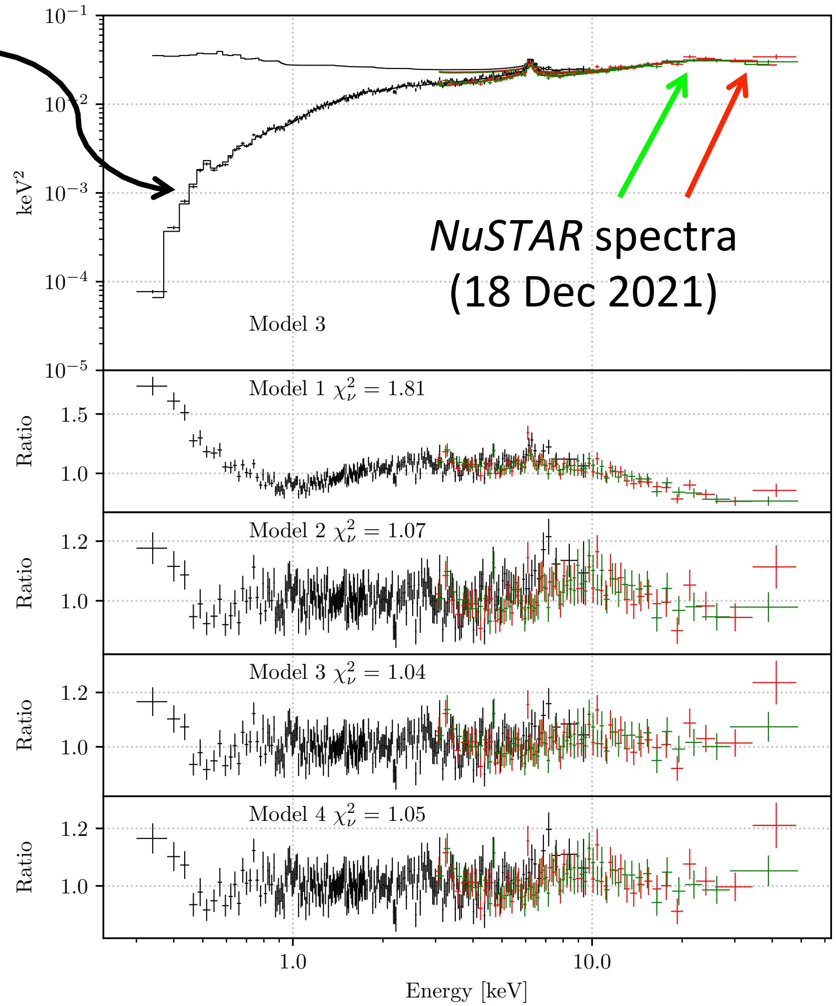
Summary

- Intensive *Swift* montioring of MGC+08-11-11 over 3 months.
- X-ray and UV-IR lightcurves are *very* highly correlated (R_{max} 0.85).
  - X-rays are driving the variability.
  - X-ray source has clear line-of-sight to reprocessor(s).
- UV-IR inter-band lags up to ≈ 3 days.
- Earlier optical monitoring revealed much longer lags (> 7 days).
  - Filtering out long-term trends reveals the faster variations.
  - Two components that dominate variability at different times.
- X-ray and UV-optical spectra suggest line-of-sight through a wind.
  - Does the wind affect the lags?
- Disc truncated by wind (or bowl geometry) broadly explains lags.
- <u>But</u> our lag spectrum also clearly shows contribution from BLR.

Extra slides

X-ray spectra

Swift time-averaged spectrum (Feb – May 2021)



Base model: `kynxillver` (Dovčiak, Karas, Yaqoob) – X-ray lamppost + GR disc reflection

#1: just Galactic absorption (bad)

#2: Gal. absorption + intrinsic (neutral) + intrinsic (ionised)

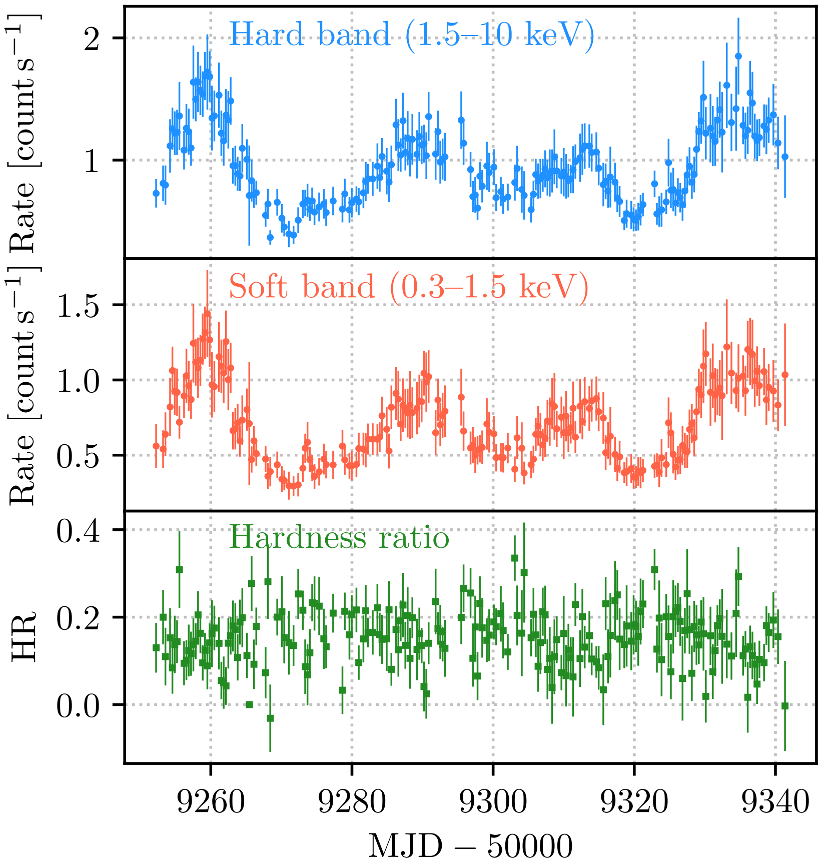
#3: Gal. absorption + intrinsic (neutral) + intrinsic (ionised) ×2

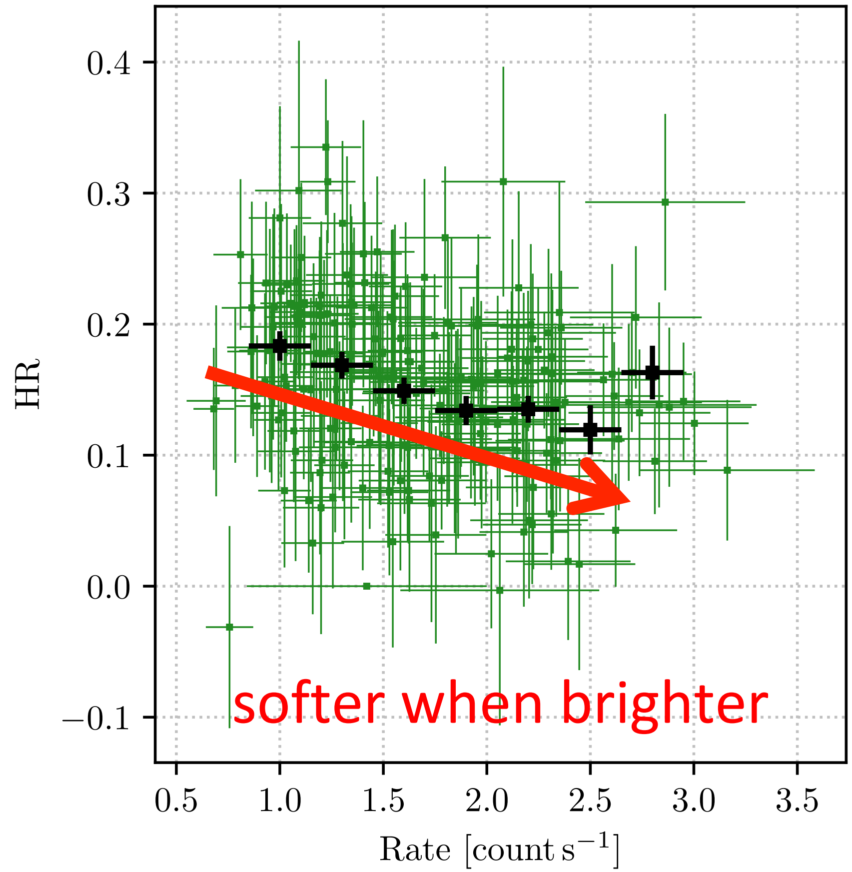
#4: Gal. absorption + intrinsic (neutral) ×2 + intrinsic (ionised)

<u>Model 3</u>

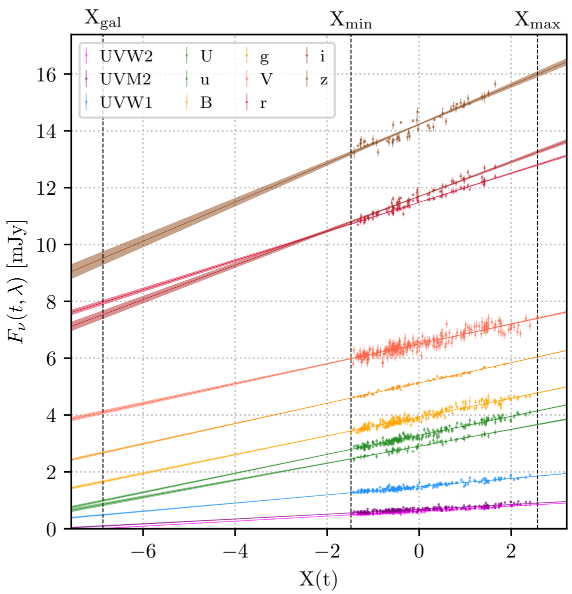
N_H (neutral)	= 7.9e20
N_H (ion. 1)	= 8.3e22
log ξ (ion. 1)	= -3.00
CF (ion. 1)	= 0.21
N_H (ion. 1)	= 7.4e21
log ξ (ion. 1)	= -0.71
CF (ion. 1)	= 0.63
Γ	= 2.11
L_X / L_{Edd}	= 0.015
log L_X / erg s^{-1}	= 43.8
E_{line} / keV	= 6.33

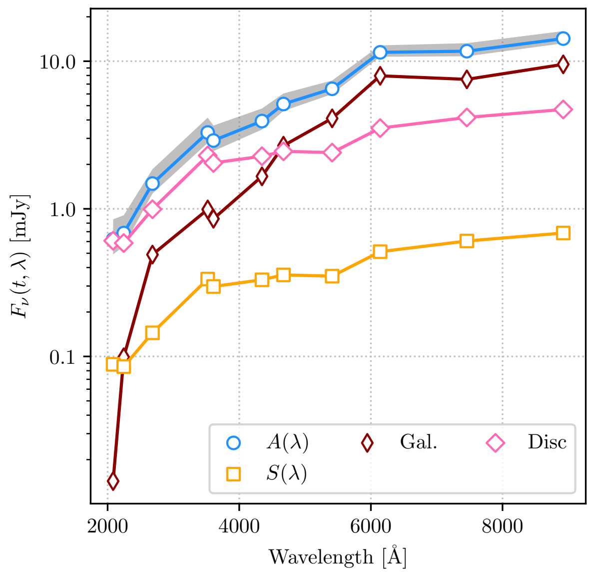
X-ray hardness

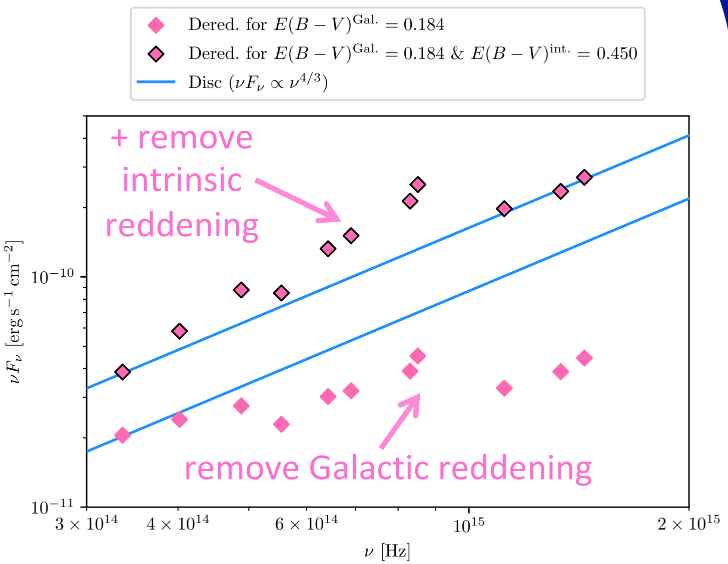




Flux-flux analysis





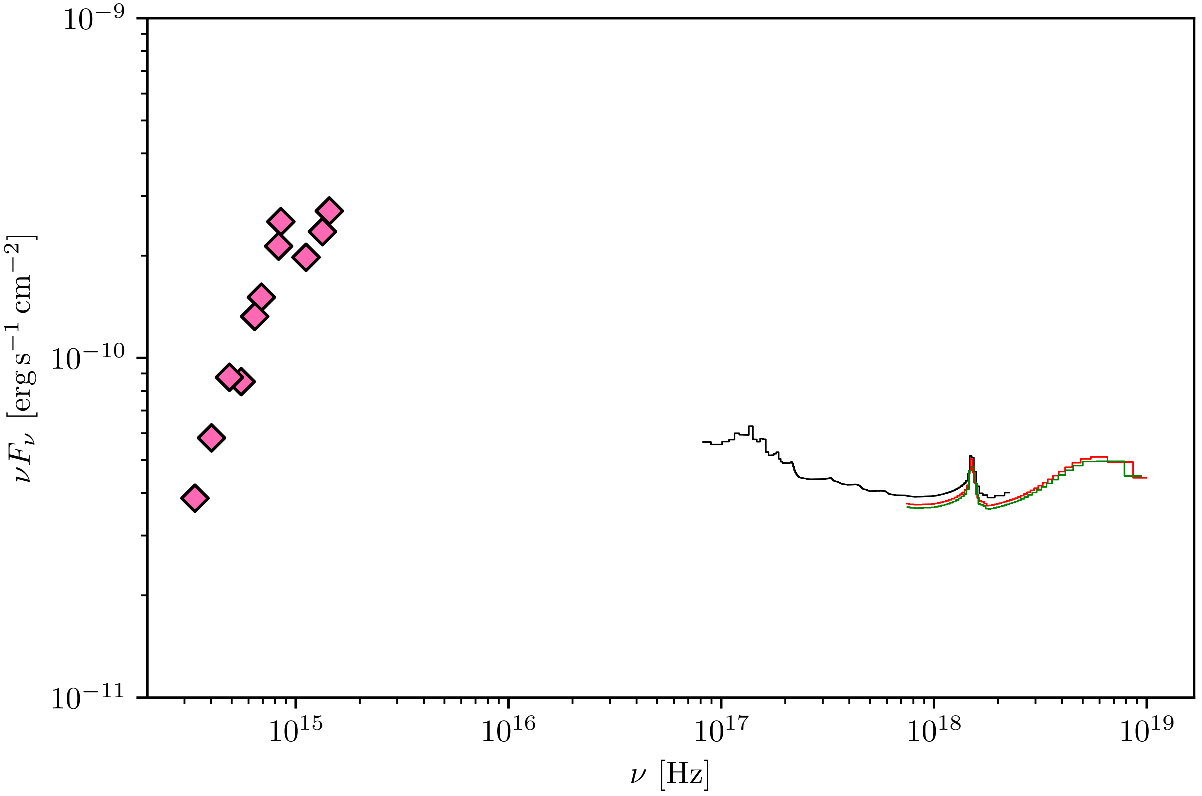


Separate out the **mean**, **variable** and **host galaxy** components, best estimate of the **disc** spectrum.

Estimated disc still redder than standard disc: implies reddening in the nucleus.

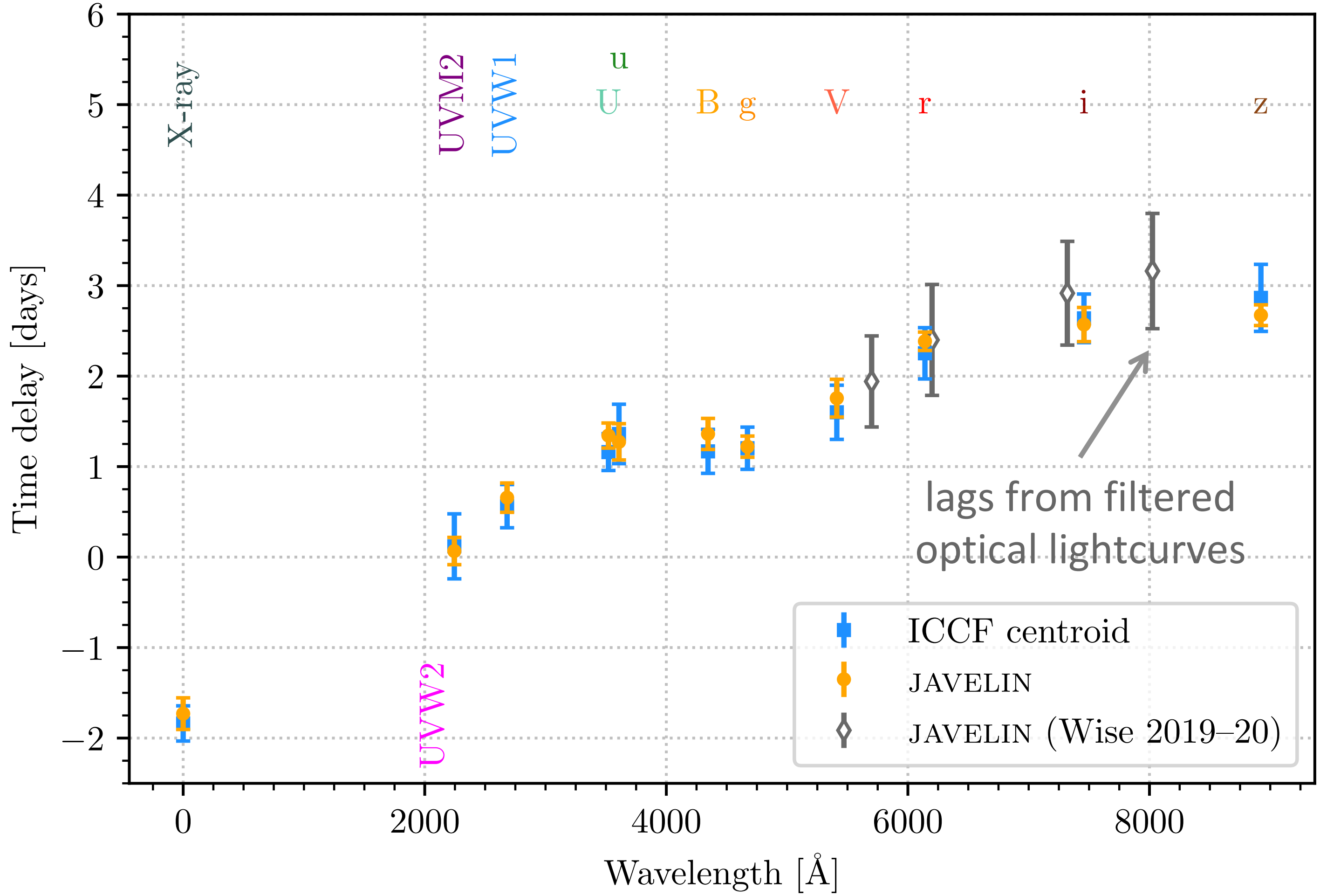
Daniel Kynoch
University of Southampton

Spectral energy distribution



The multifaceted variability of the Seyfert AGN MCG+08-11-11

Lag spectrum

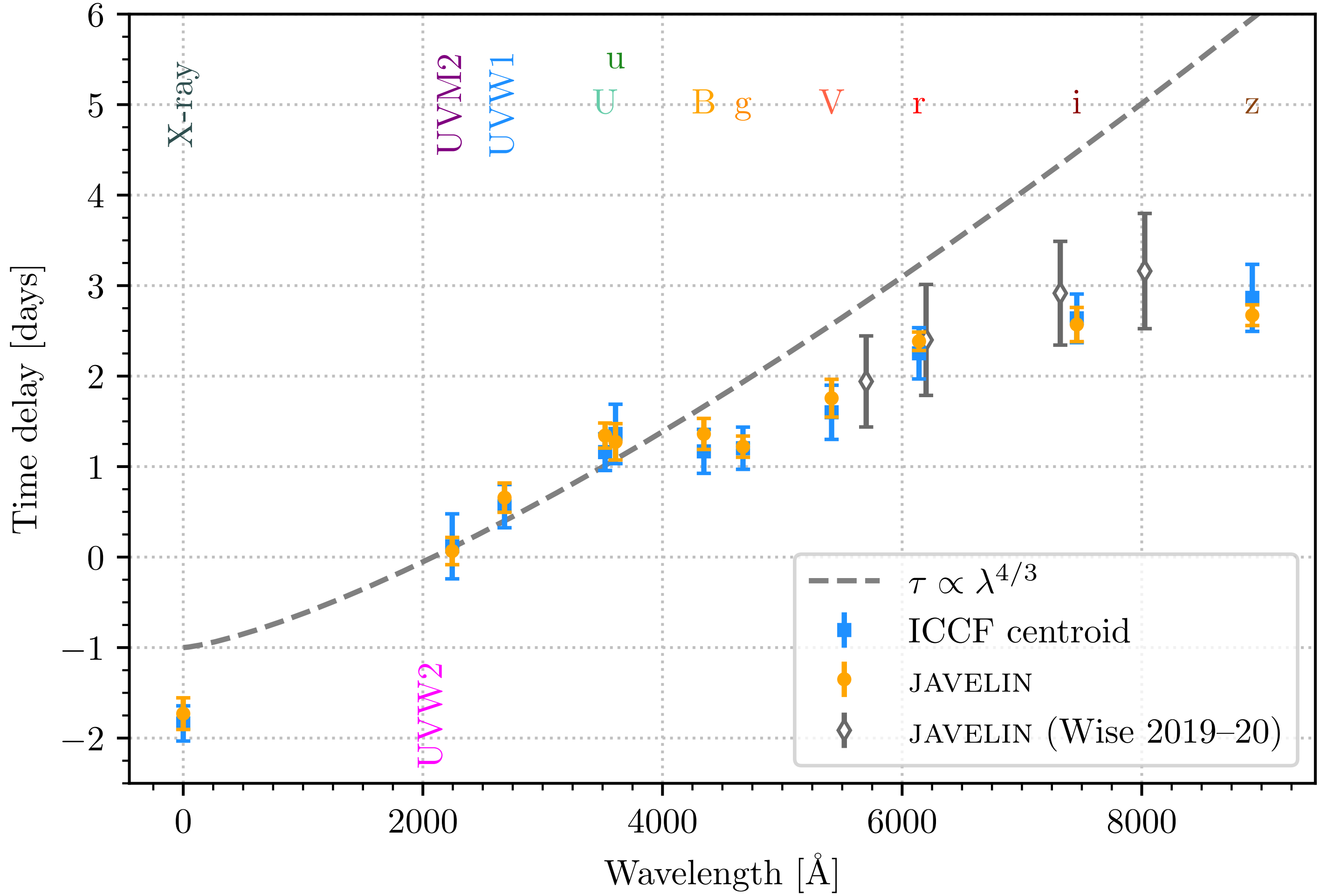


Daniel Kynoch

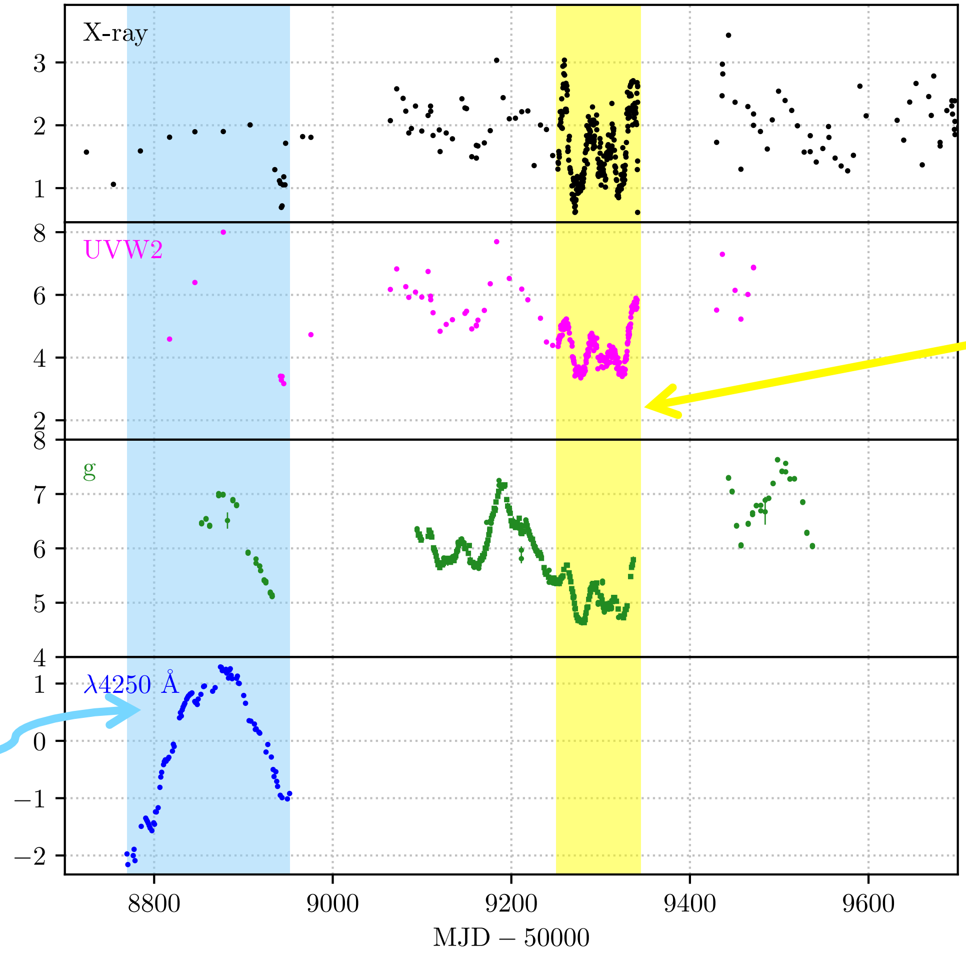
The Restless Nature of AGN | Napoli | June 2023

University of Southampton

Lag spectrum



Long-term trends



Swift campaign 2021

Optical campaign 2019-20 (Fian 2023)