

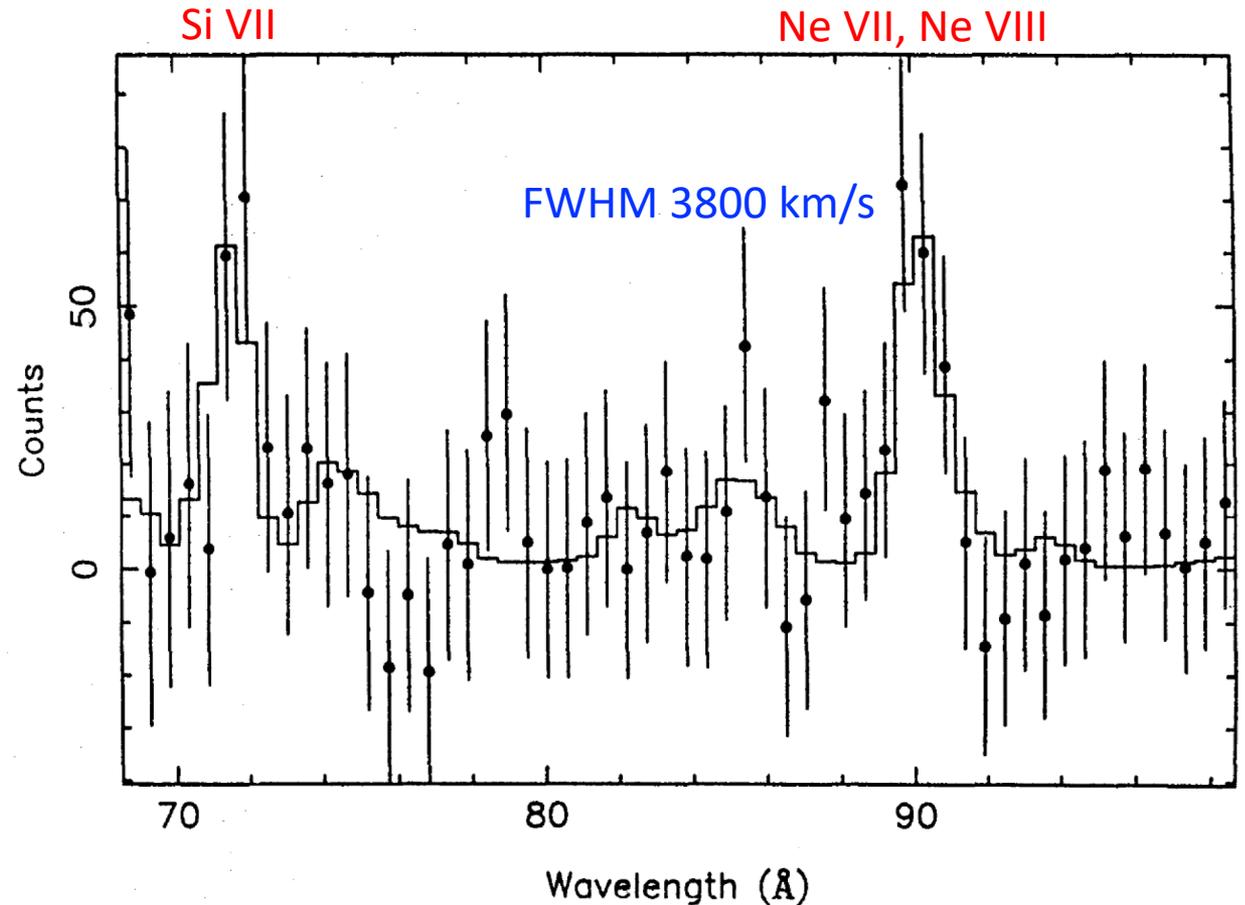
A new era of AGN outflow studies initiated by Chandra's LETGS

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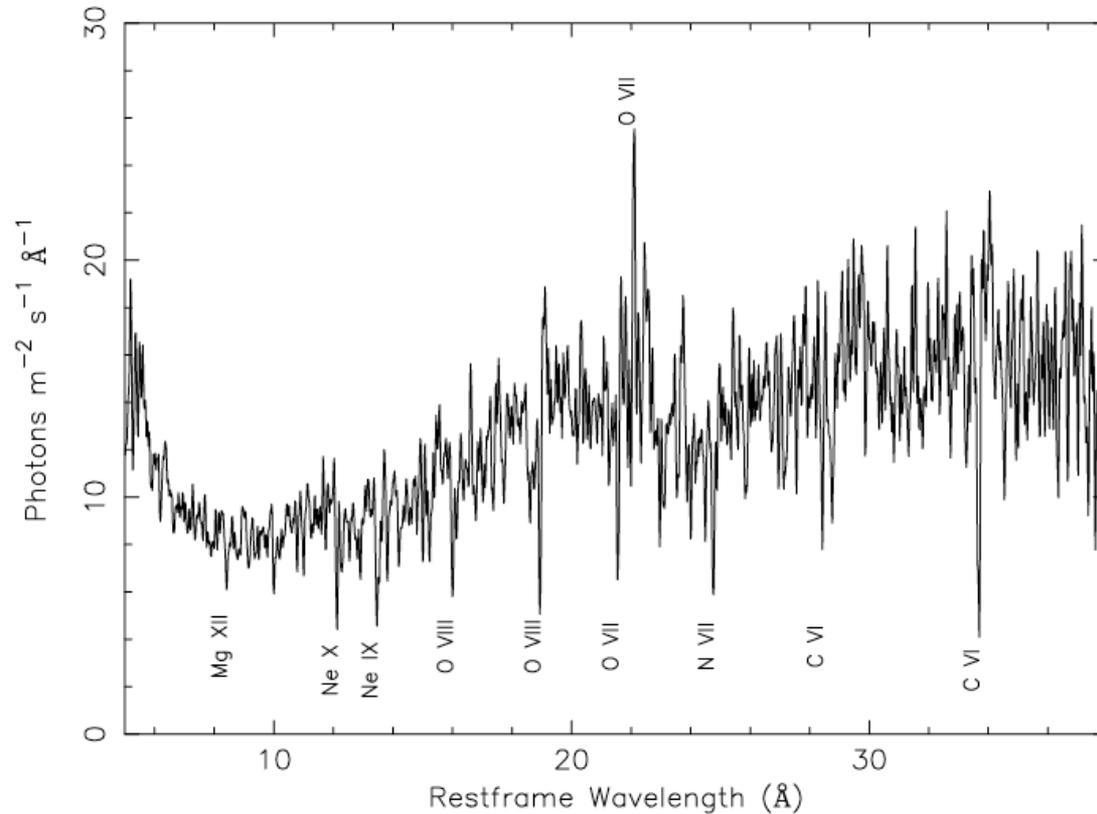
NGC 5548: Prehistory

- NGC 5548 prototype Seyfert 1 galaxy
- Studied since early days X-ray astronomy
- EUVE showed some evidence for broad emission lines



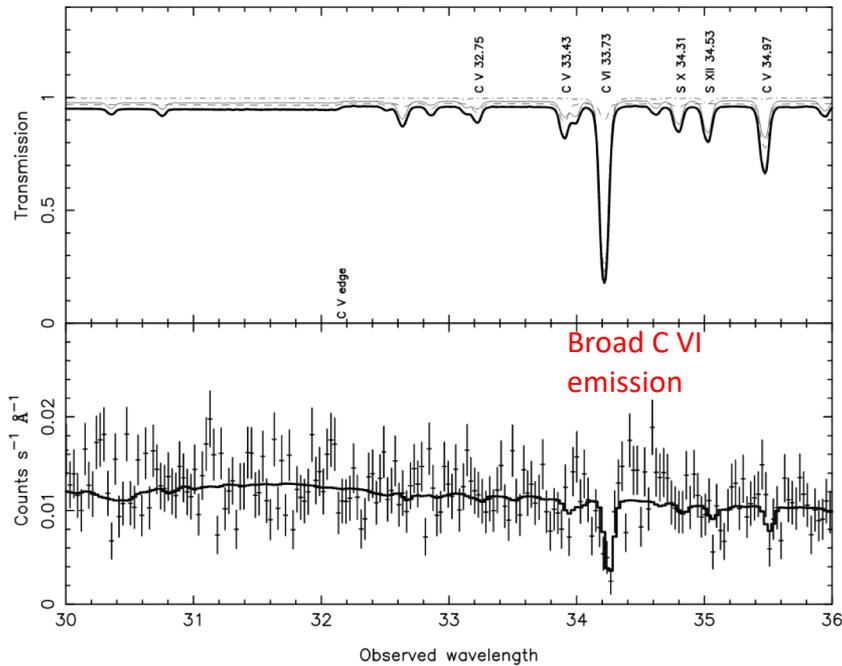
EUVE, 332 ks (Kaastra, Roos & Mewe 1995)

First high-resolution spectrum of an AGN

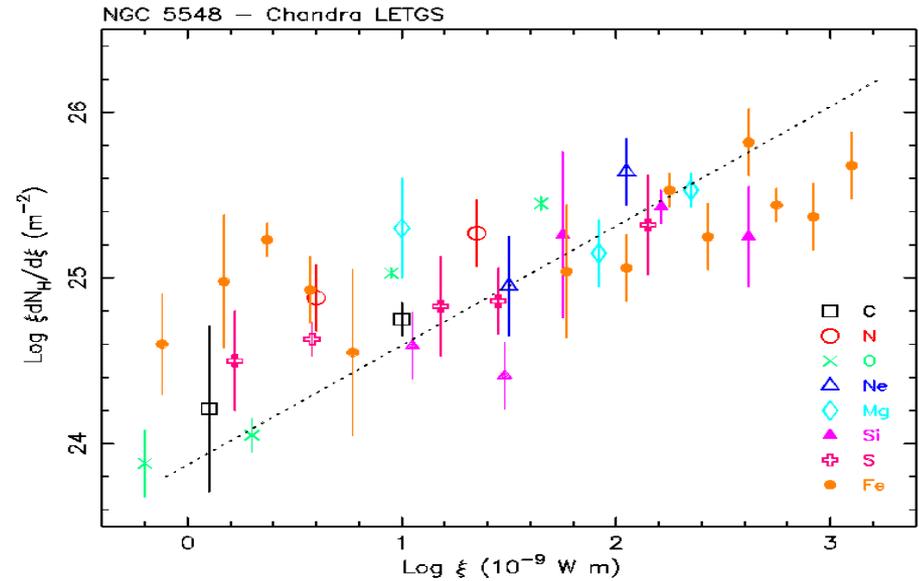


NGC 5548, 11 December 1999, 86 ks, [Chandra LETGS](#)
Blueshifted absorption lines from photoionised gas: wind
(Kaastra et al. 2000)

Broad X-ray emission lines & absorption measure distribution



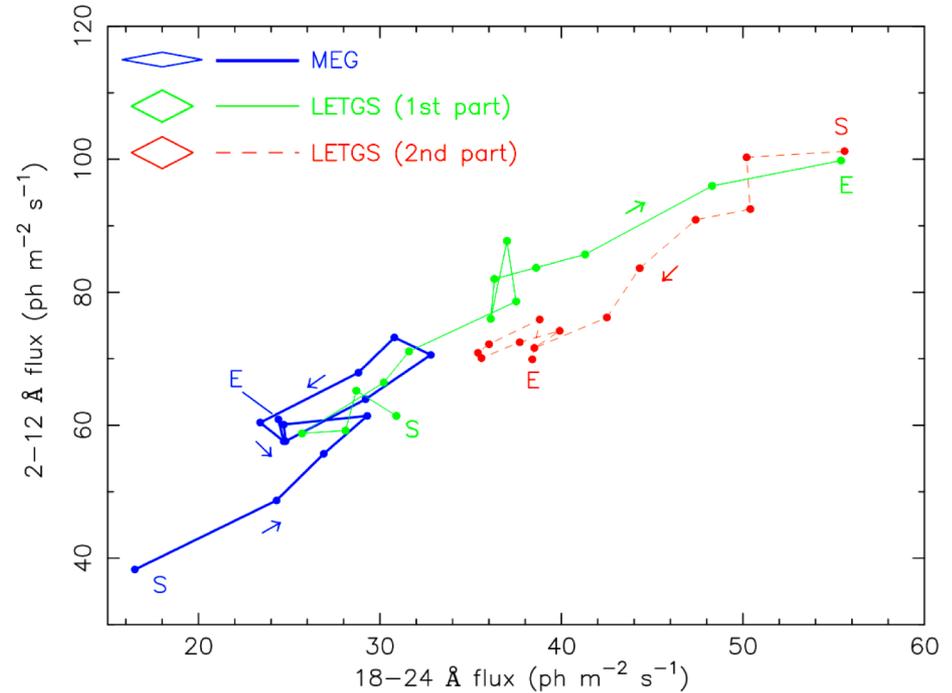
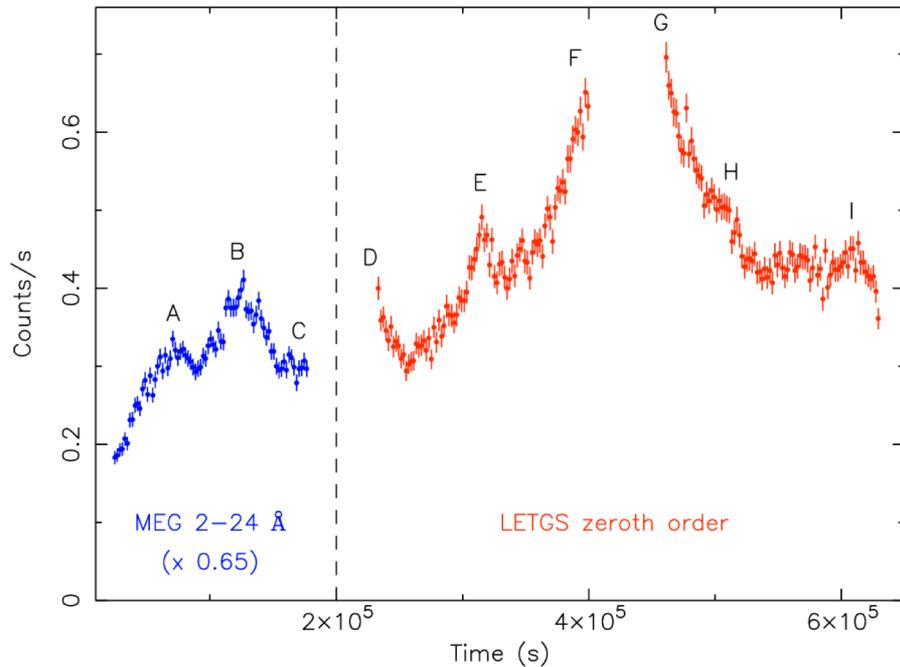
1999 LETGS spectrum (86 ks)
(Kaastra et al. 2002)



2002 LETGS spectrum (345 ks)
(Steenbrugge et al. 2005)

Quasi-periodic oscillations

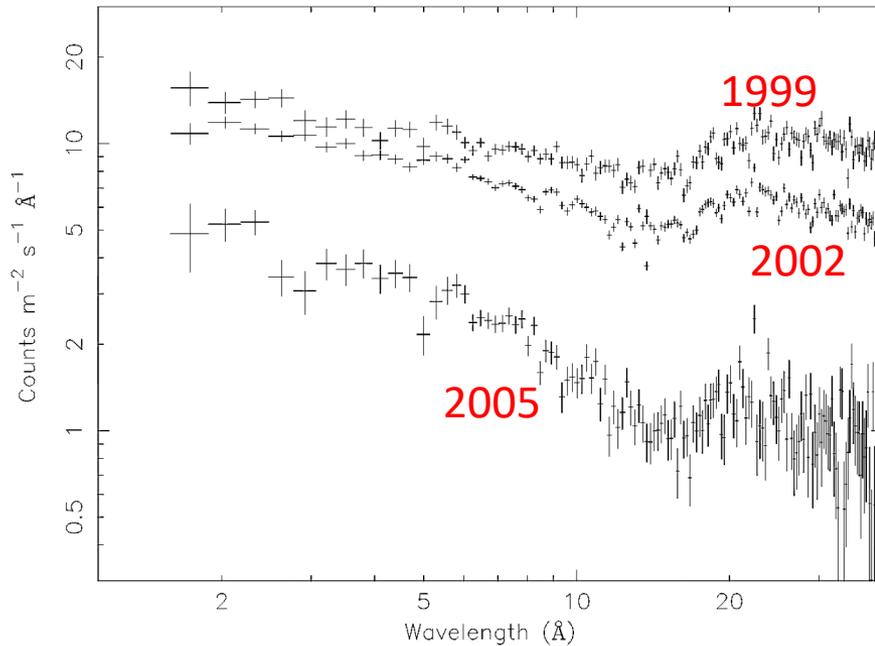
(Kaastra et al. 2004)



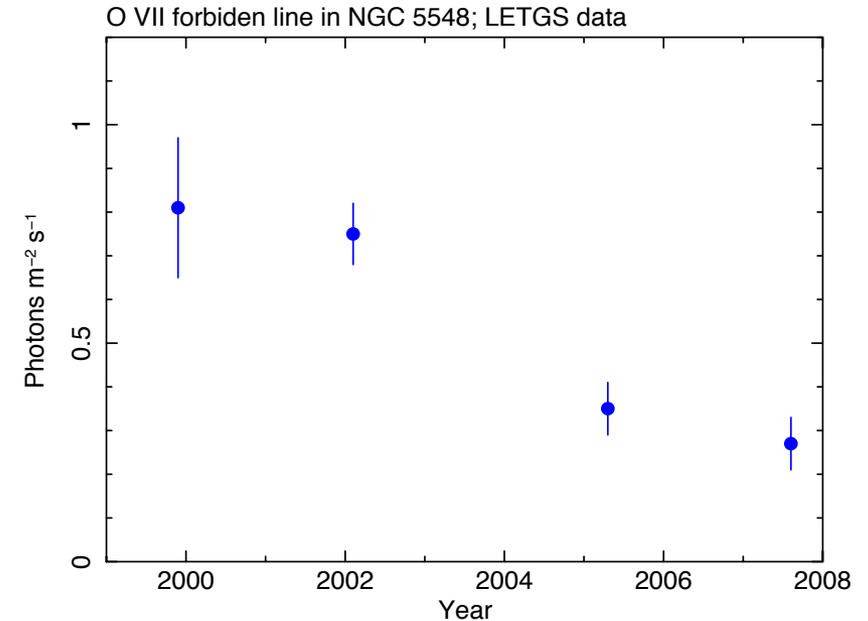
- Quasi-periodic variations
- duration few hours
- hard X-rays delayed by few hours
- evidence for rotating spot at $10 r_g$

The lean years

(Detmers et al. 2008, 2009)



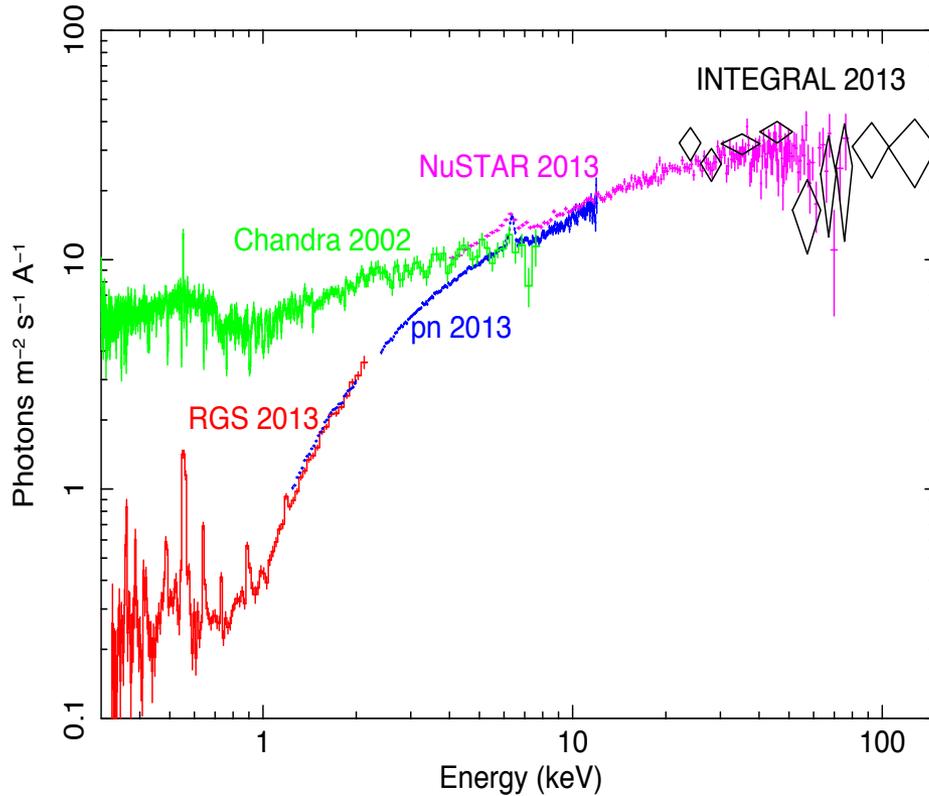
Low continuum flux in 2005 and even worse in 2007



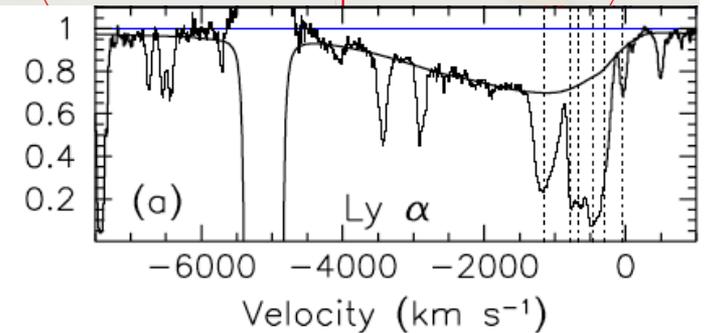
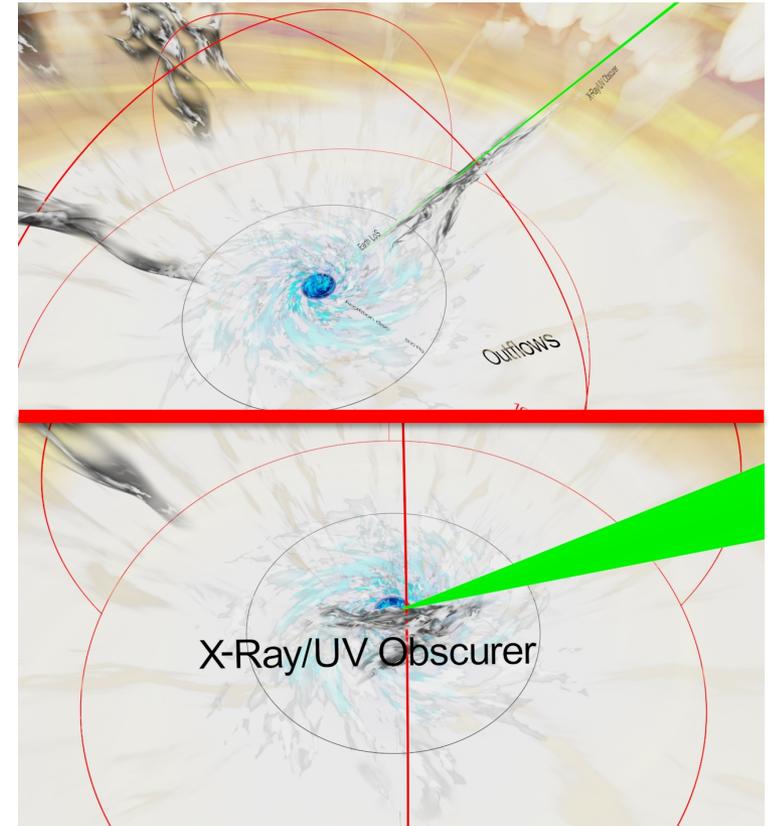
“Every disadvantage has its advantage” (Johan Cruijff)

Narrow O VII line variability limits its distance to pc-scale

Obscuration in NGC 5548

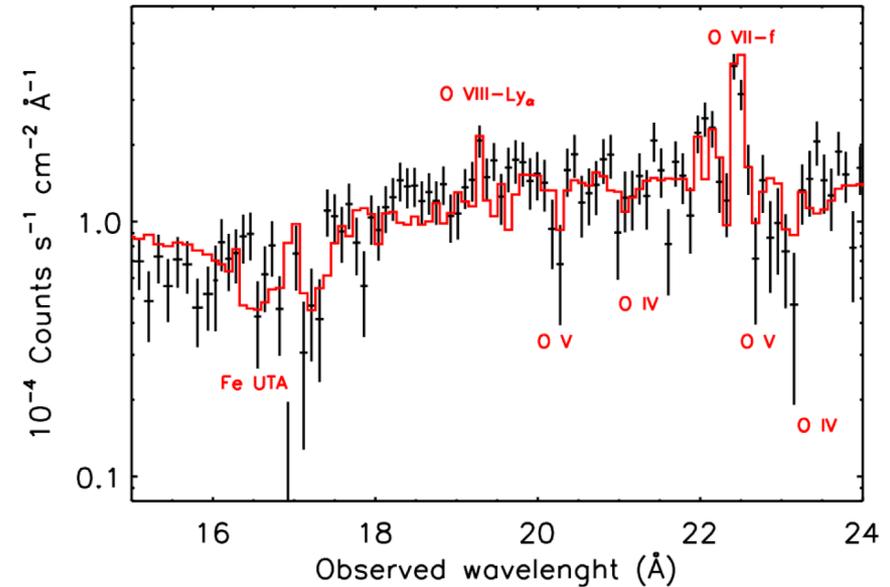
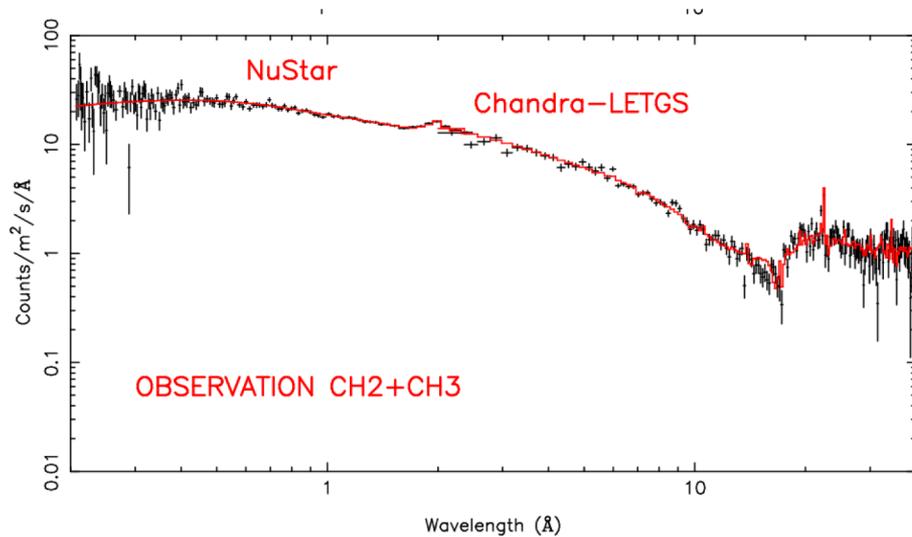


- High column density, low ionisation, partial covering, outflowing gas in line of sight
- shields major part ionising radiation
- profound effect on material behind it (Kaastra et al. 2014)



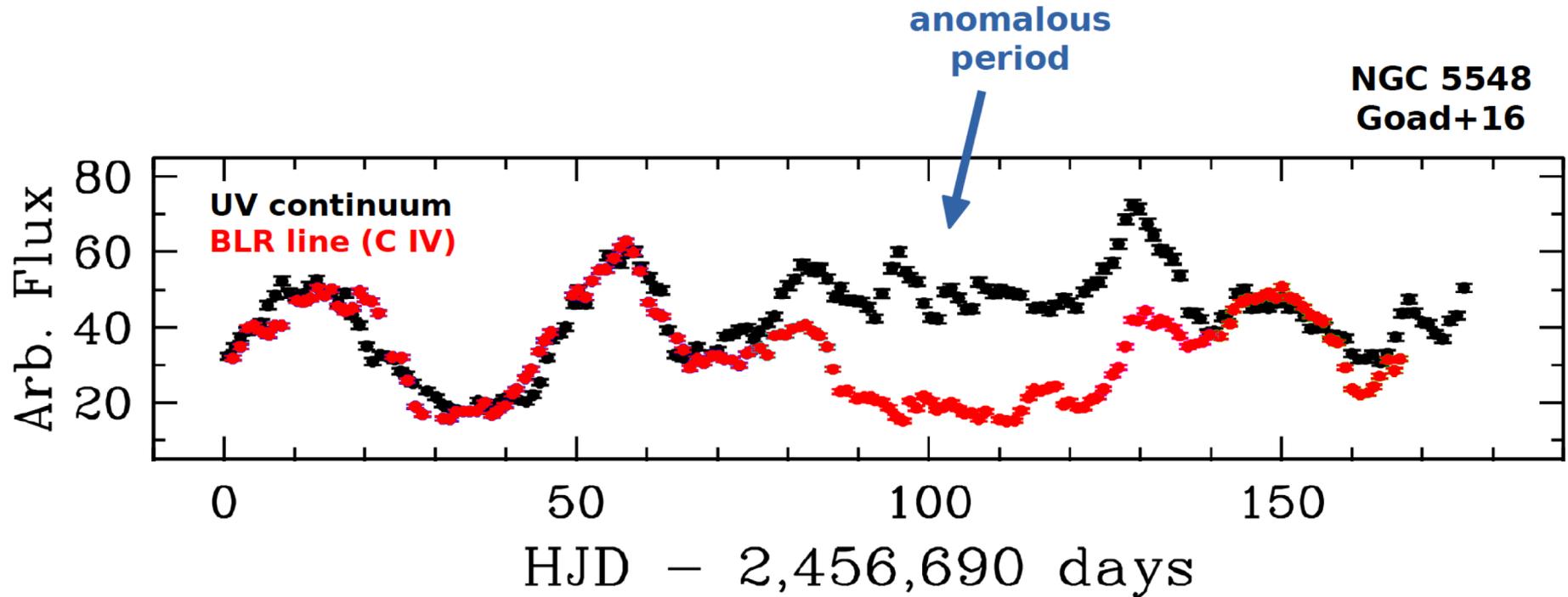
X-ray spectrum in obscuration

(Di Gesu et al. 2015)



- During 2013 obscuration, NGC 5548 showed continuum flare in Sept 2013
- Chandra ToO follow-up success:
- Allowed to find narrow absorption lines of recombined wind with LETGS

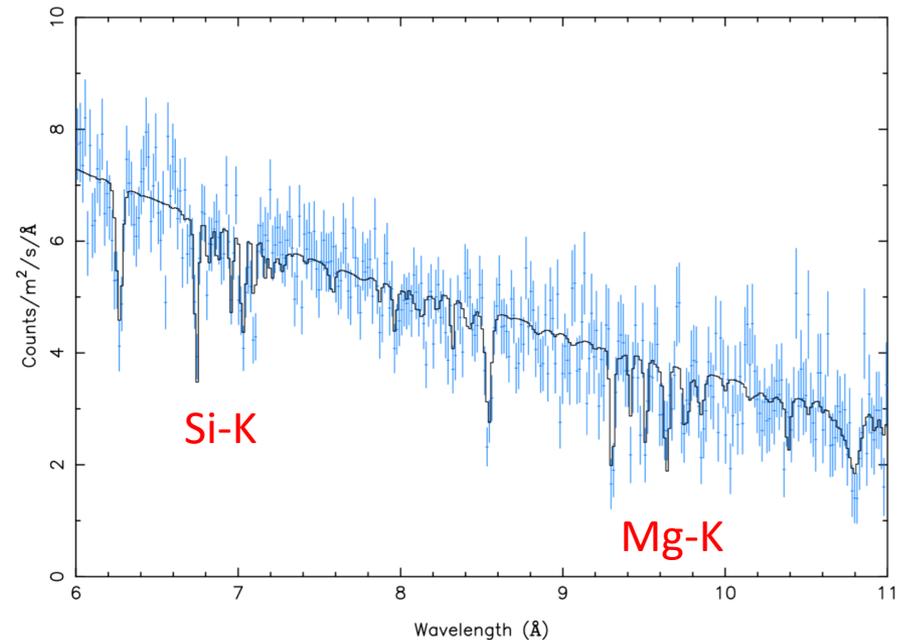
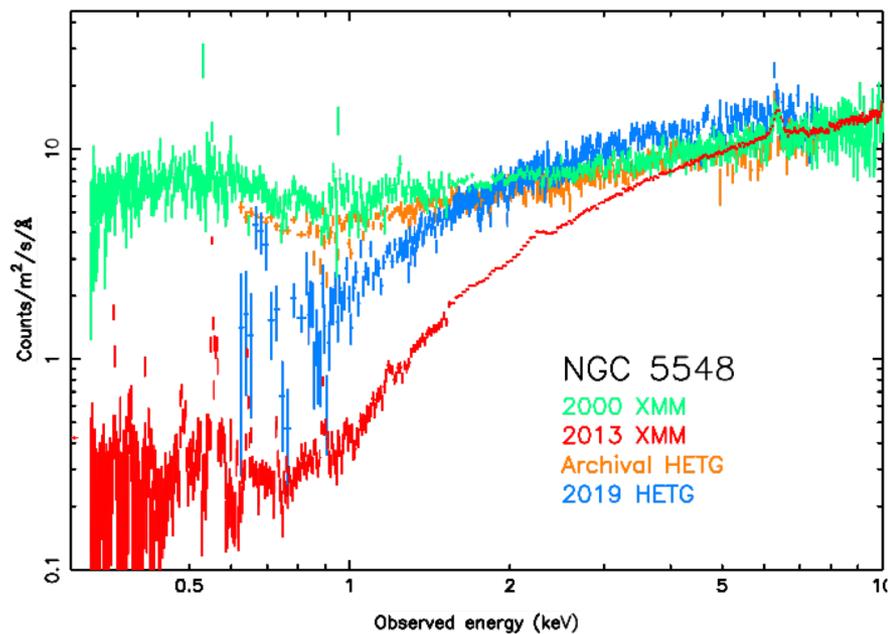
Broad line region holiday



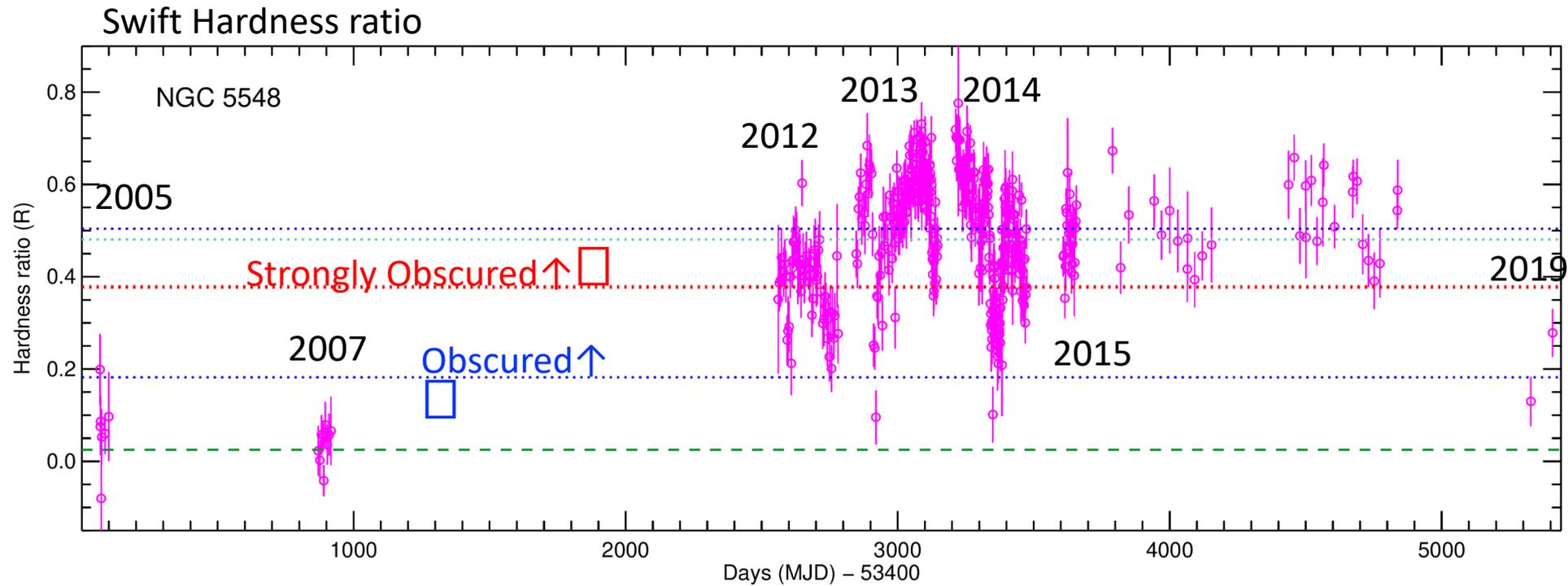
Due to changes EUV continuum caused by obscuration found in X-rays
Chandra LETG/ACIS observations confirm this
(Mathur et al. 2017; Dehghanian et al. 2019)

Latest Chandra spectra: 2019 still obscured, but dawning?

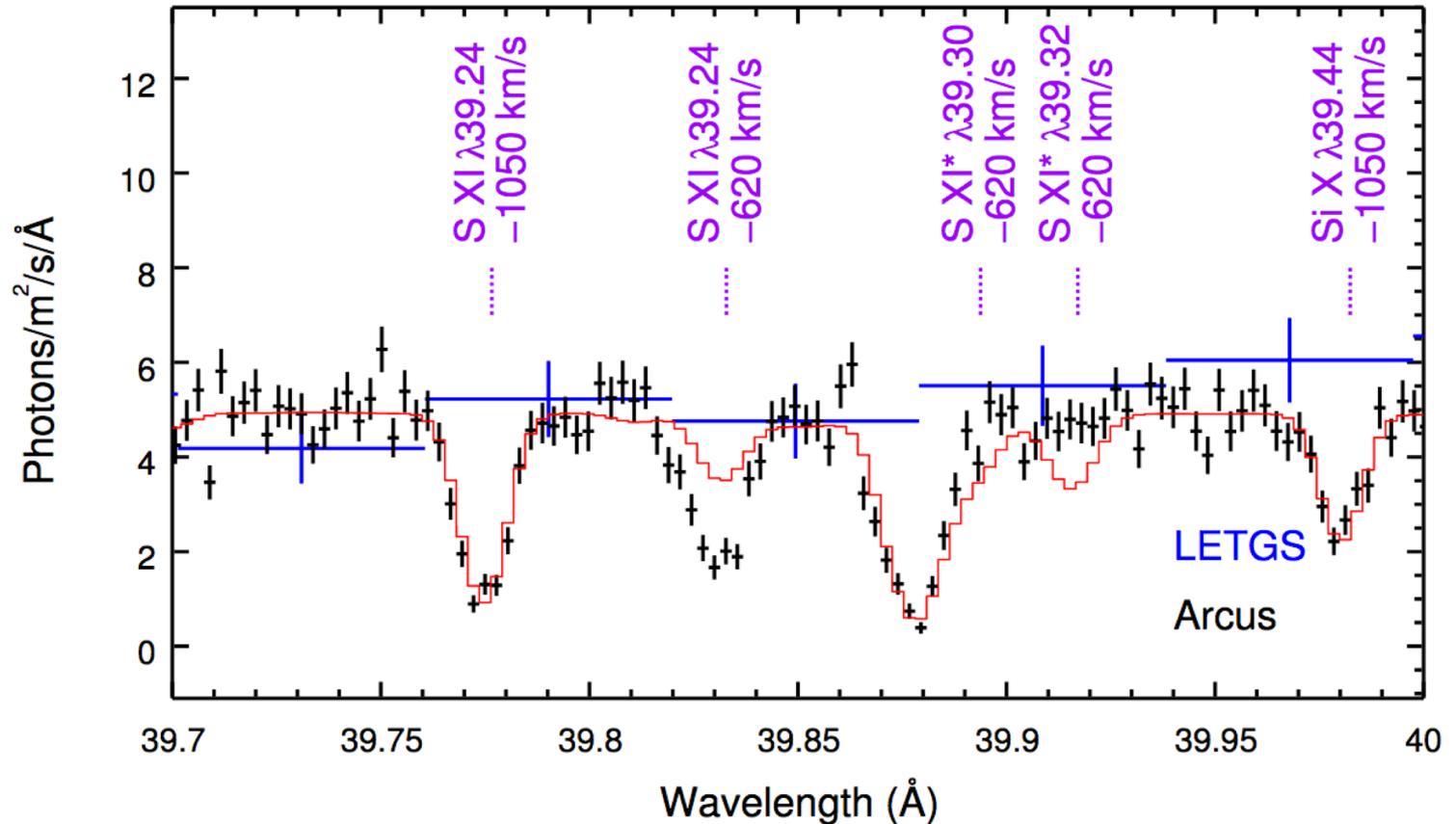
(Mehdipour et al., in prep.)



When will darkness end?



The future: Arcus



NGC 5548, LETGS observed 345 ks in 2002

Arcus simulated 345 ks, density 10^6 m^{-3}

Arcus model, density 10^{16} m^{-3}

(Kaastra et al. 2017)

Conclusions

- NGC 5548 is a fabulous source showing an wide range of AGN behaviour
- Chandra LETGS has been fundamental in discovering new phenomena in this source and others
- We are eagerly waiting for more Chandra spectra and a worthy successor of it
- **Congratulations, Chandra!**