X-ray absorption variability in NGC 4507

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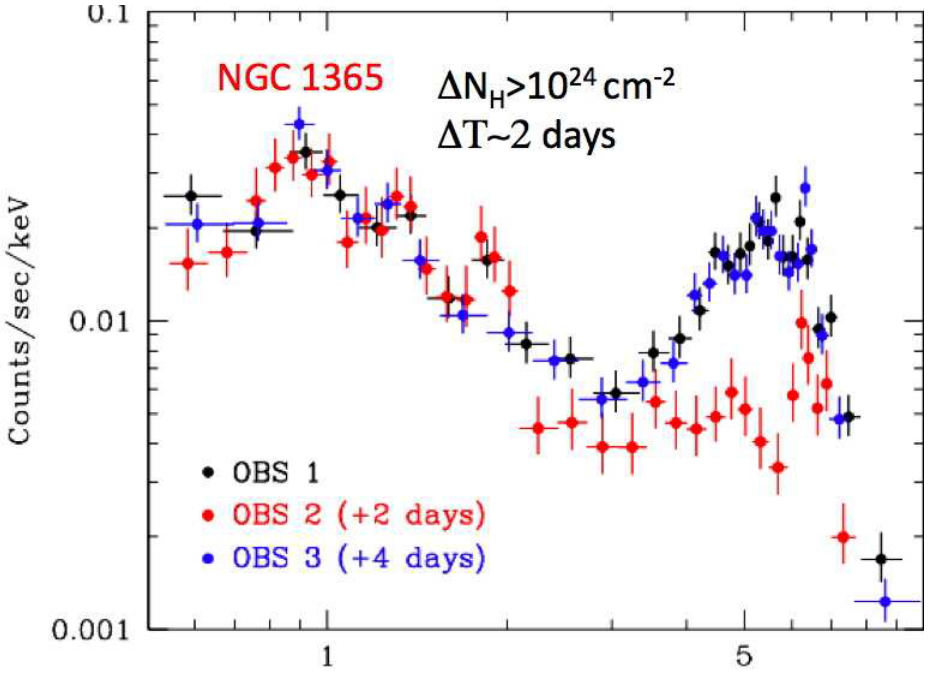
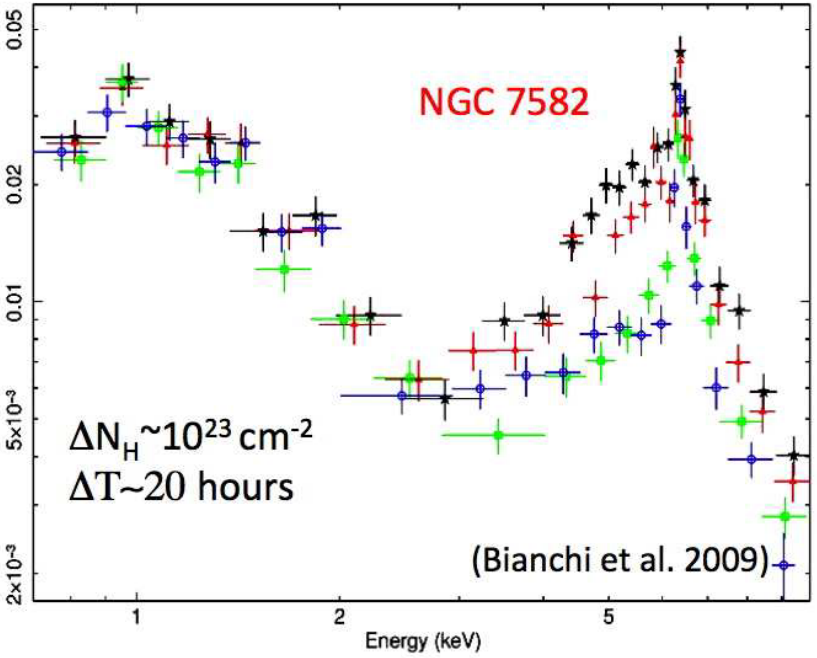
X-ray absorption variability

Nearby obscured AGNs with multiple X-ray observations showed that N_H variations are a common feature of local Seyfert galaxies (Risaliti et al. 2002).
XMM-Newton, *Suzaku* and *Chandra* revealed that the circumnuclear X-ray absorber is located at sub-parsec distances from the central source.

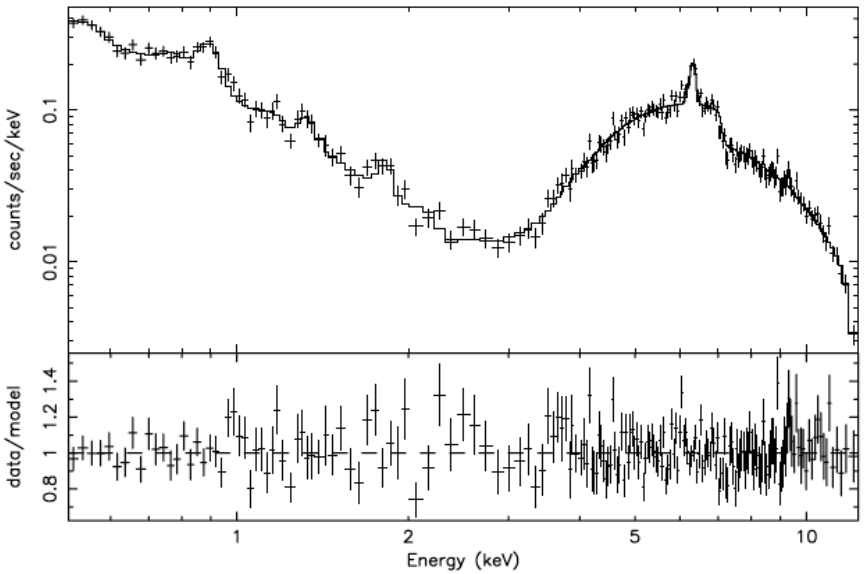


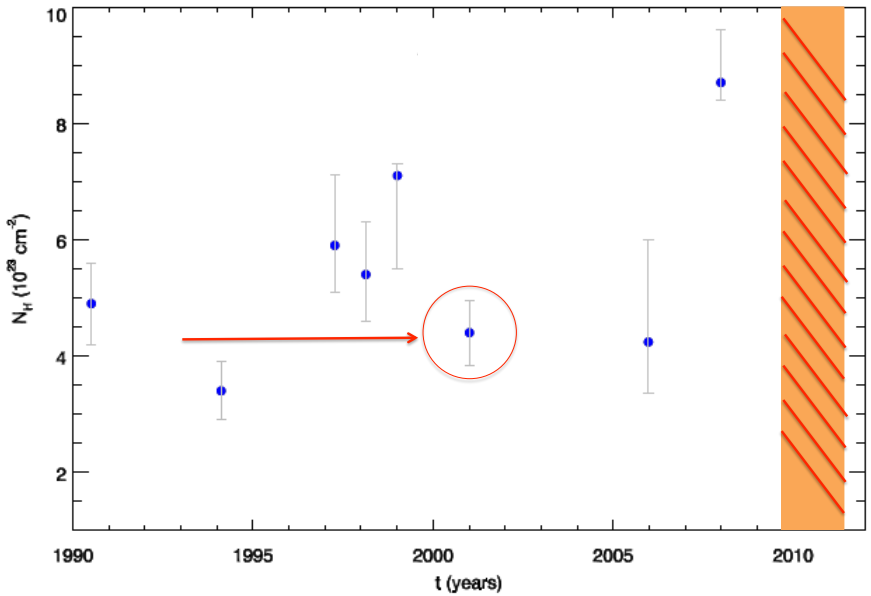


Such rapid events imply that absorption is due to fast moving clouds ($\sim 10^3$ km s^{-1}) at distances of the order of 10^4 R_g, which are typical values for the Broad Line Region.

N_H variability in NGC4507

NGC 4507 is a nearby (z = 0.0118) spiral galaxy and one of the X-ray brightest Compton-thin Seyfert 2s, despite the heavy obscuration.



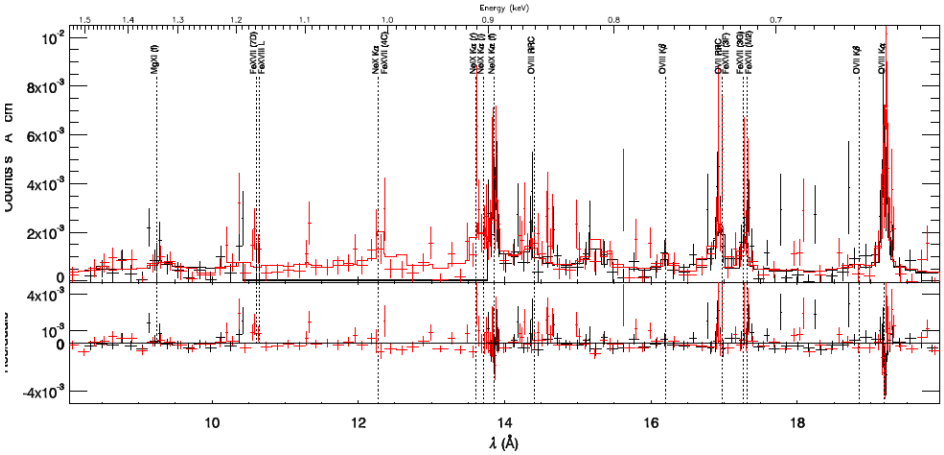


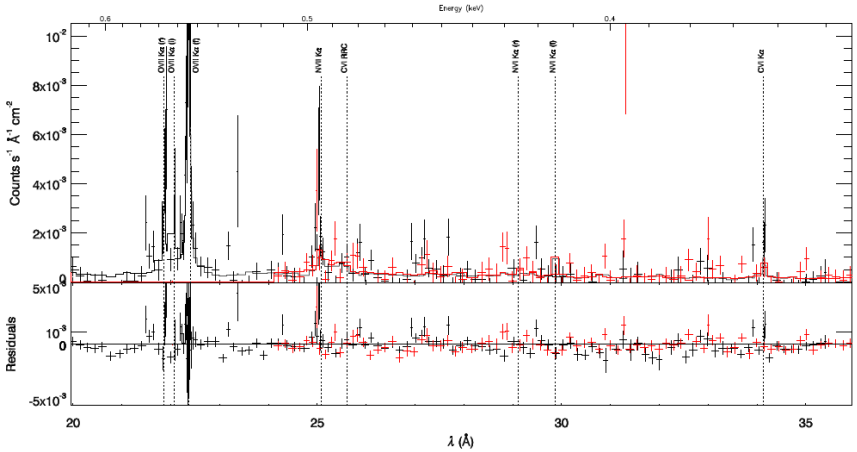
Our campaign in 2010:

Date	Obs. Id.
June 24	XMM1 - 0653870201
July 3	XMM2 - 0653870301
July 13	XMM3 - 0653870401
July 23	XMM4 - 0653870501
August 3	XMM5 - 0653870601
December 2	Chandra - 12292

Data analysis: RGS1+RGS2

Due to the good quality of the RGS spectrum, we used a self-consistent model to reproduce the whole spectrum in a wavelength range from 8 $\AA$ up to 35 $\AA$. We produced a grid model for XSPEC using CLOUDY 08.00 . It is an extension of the model used in Bianchi et al. (2010).





Final Cash/dof= 5470/4567.

$\log U_1 = 2.37^{+0.58}_{-0.28}$, $\log U_2 = 0.56^{+0.19}_{-0.22}$

$\log N_{H_1} = 22.15^{+0.48}_{-0.70}$ and $\log N_{H_2} = 21.95^{+0.27}_{-0.23}$

kT=$0.40^{+0.18}_{-0.08}$

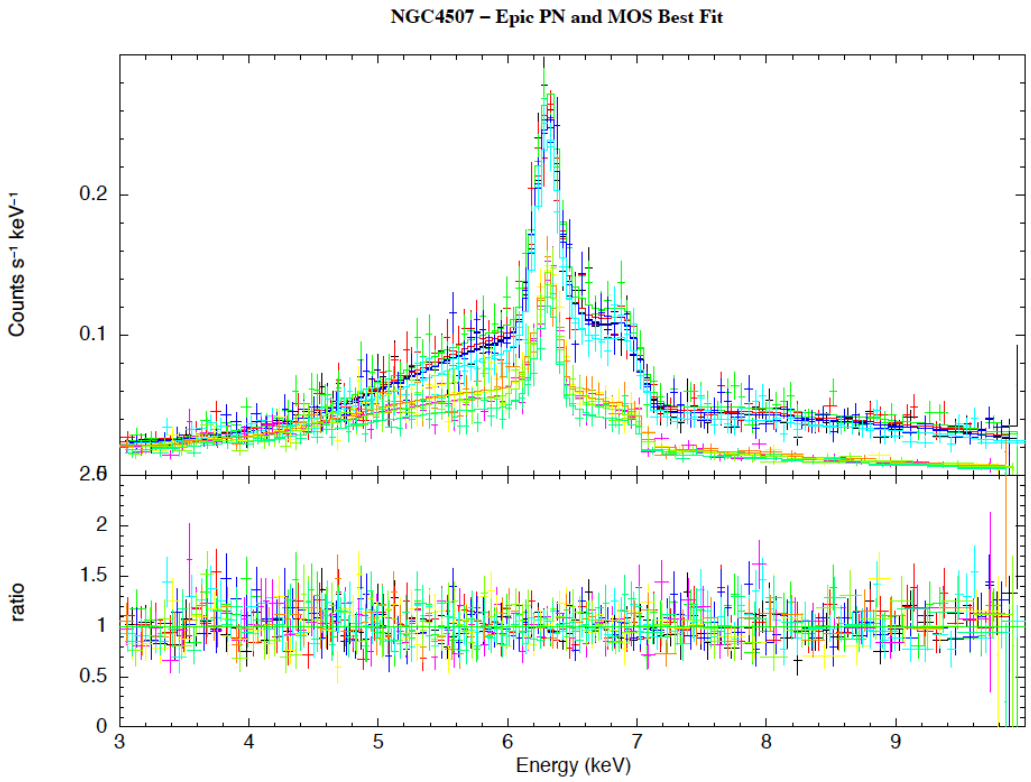
Data analysis: RGS1+RGS2

Energies are in keV units, wavelengths in $\AA$, fluxes in 10^{-5} ph cm^{-2} s^{-1}.

Line Id.	λ_T	E_T	**Energy**	**Fluxes** (a)	Total (b)	U_1 (c)	U_2 (d)	kT (e)
C VI Kα	33.736	0.367	$0.3674^{+0.0005}_{-0.0005}$	$2.2^{+1.9}_{-1.8}$	2.7	0.5	2.1	0.1
C VI RRC	25.303	0.490	$0.485^{+0.001}_{-0.003}$	$3.0^{+2.0}_{-1.4}$	1.8	0.4	1.4	0.04
	22.101	0.561 (f)	$0.561^{+0.0005}_{-0.0005}$	$9.2^{+1.2}_{-1.4}$	8.6	0.02	8.5	0.07
O VII Kα	21.807	0.569 (i)	$0.5683^{+0.0005}_{-0.001}$	$0.7^{+0.7}_{-0.6}$	2.1	-	2.0	0.02
	21.602	0.574 (r)	$0.5731^{+0.0004}_{-0.0004}$	$2.4^{+0.9}_{-0.8}$	1.9	0.03	1.7	0.2
O VIII Kα	18.968	0.654	$0.6534^{+0.0004}_{-0.0004}$	$2.3^{+0.4}_{-0.4}$	2.6	0.8	0.9	0.8
O VII Kβ	18.627	0.666	$0.670^{+0.002}_{-0.002}$	$0.5^{+0.3}_{-0.3}$	0.08	-	0.05	0.03
O VII RRC	16.769	0.739	$0.739^{+0.001}_{-0.001}$	$1.3^{+0.4}_{-0.4}$	1.4	-	1.2	0.2
O VIII Kβ	16.005	0.775	$0.773^{+0.001}_{-0.001}$	$0.6^{+0.2}_{-0.2}$	0.2	0.04	0.03	0.1
O VIII RRC	14.228	0.871	$0.871^{+0.004}_{-0.003}$	$1.3^{+0.3}_{-0.3}$	1.2	0.6	0.4	0.2

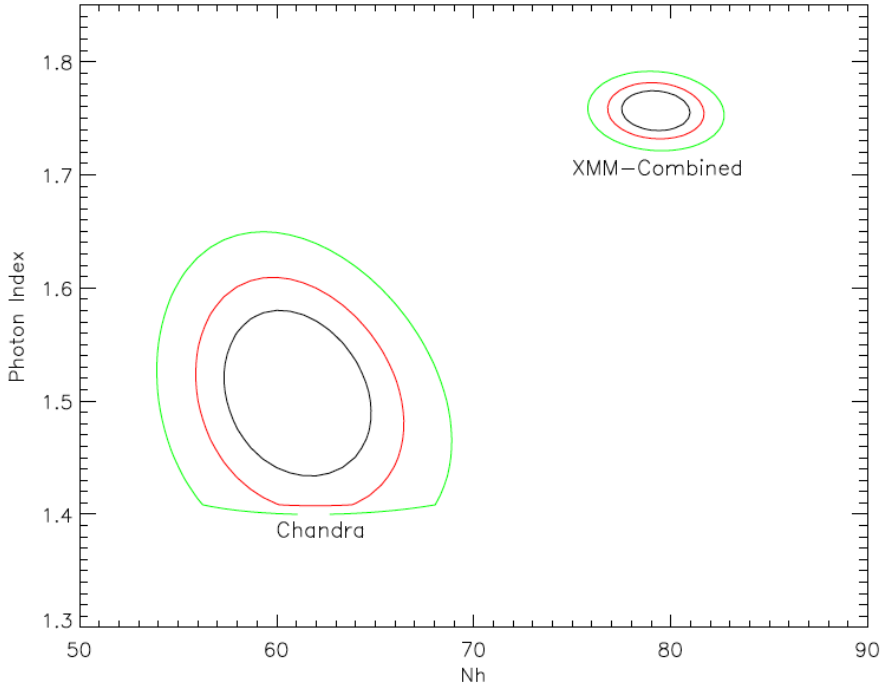
Data analysis: 5 Epic Pn + 5 Epic MOS spectra

$$F(E) = e^{-\sigma(E)N_H^G}[Ph_C + C + e^{-\sigma(E)N_H}BE^{-\Gamma} + R(\Gamma) + \sum_i G_i(E)]$$



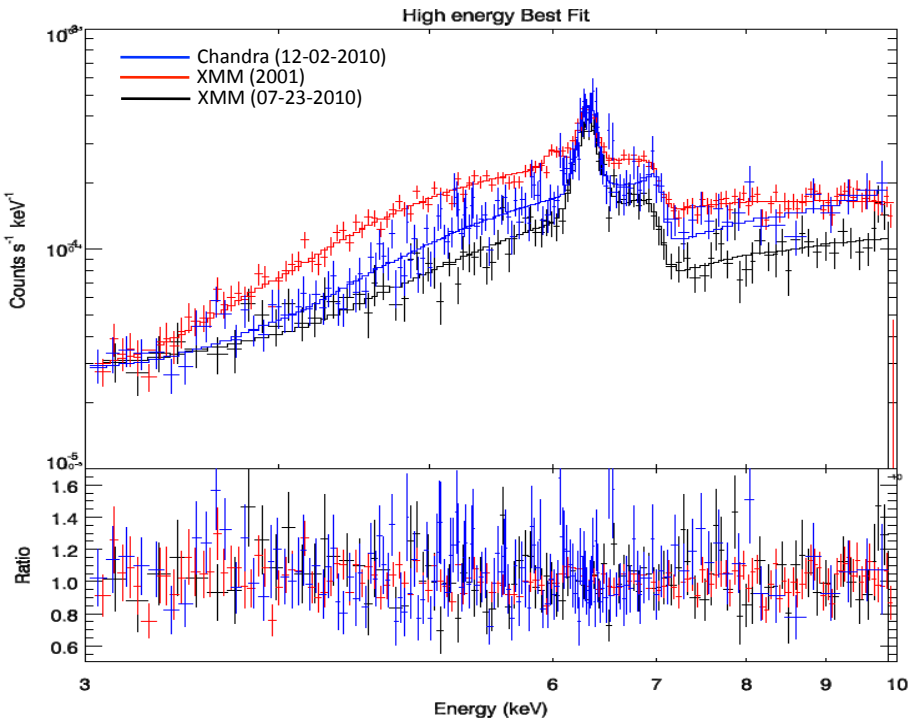
- Photoionised gas reproduced with self-consistent CLOUDY models
- Collisionally-ionised diffuse gas (APEC)
- Strongly absorbed powerlaw ($N_H = 7.9^{+0.1}_{-0.1} \times 10^{23}$ cm $^{-2}$)
- Pure cold reflection component (PEXRAV)
- Emission lines

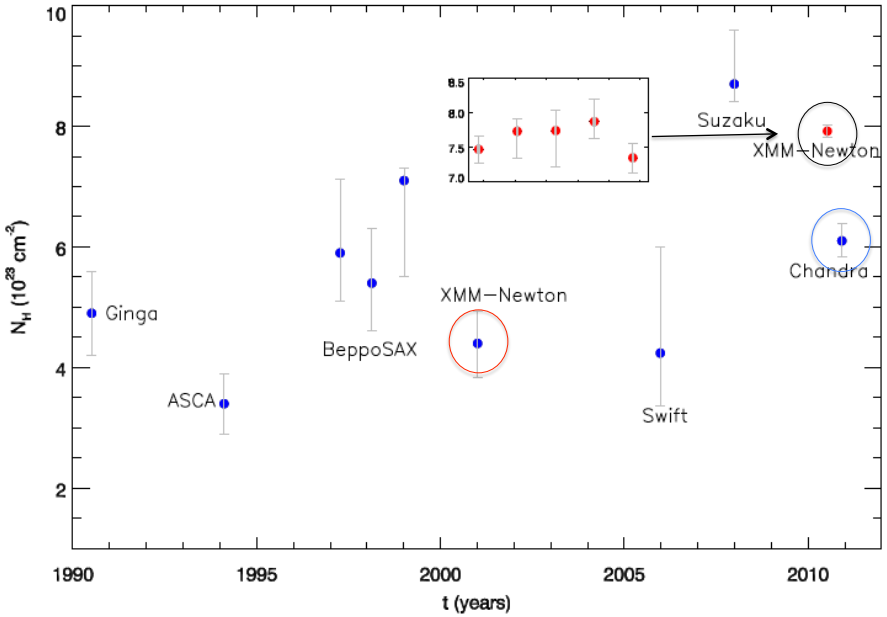
Data analysis: best fit results



Parameter	Chandra	XMM
N_h (10^{23} cm $^{-2}$)	$6.1^{+0.3}_{-0.3}$	$7.9^{+0.1}_{-0.1}$
Γ	$1.57^{+0.03}_{-0.04}$	$1.77^{+0.01}_{-0.01}$
KT (keV)	$0.40^{+0.08}_{-0.07}$	$0.60^{+0.03}_{-0.04}$
$\log U_1$	$2.01^{+0.04}_{-0.05}$	$2.51^{+0.07}_{-0.07}$
$\log N_{H1}$	$22.24^{+0.09}_{-0.07}$	$22.18^{+0.02}_{-0.02}$
$\log U_2$	$0.86^{+0.07}_{-0.07}$	$0.84^{+0.01}_{-0.01}$
$\log N_{H2}$	$21.52^{+0.10}_{-0.10}$	$21.49^{+0.01}_{-0.01}$
χ^2/d.o.f.	314/328	1680/1464

Data analysis: 3-10 keV comparison





$$\Delta N_H = 1.8 \times 10^{23}\ \mathrm{cm}^{-2} \text{ at } \sim 6\sigma \text{ level.}$$

$\Delta t = 4$ months $\rightarrow$ These time scales rule out absorption from BLR clouds.

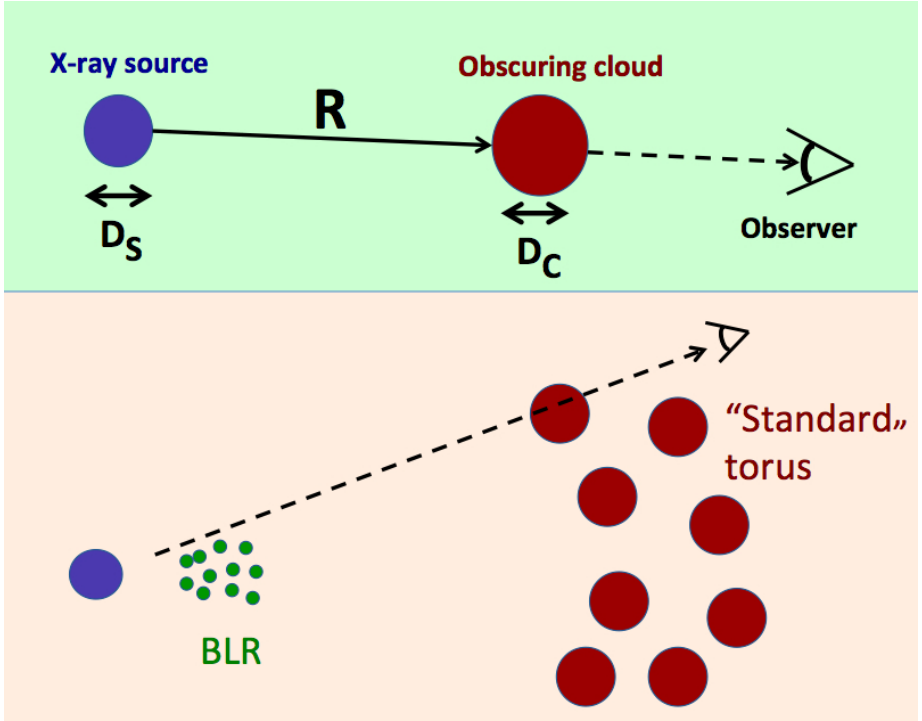
Absorption variability in a standard Torus

$D_C \sim v_k \times T_{cr}$
with our results
($T_{cr} = 10^7$ s):
$v_k = 150\ M_{7.65}$ km s^{-1}

$\downarrow$

$R = 9\ M_{7.65}^{-1} \mathrm{D}_{10}^{-2}$ pc

where:
$\mathrm{D}_{10} = D_S/10\mathrm{R}_g$
$M_{7.65} = M_{bh}/10^{7.65}\mathrm{M}_\odot$



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Summary

- We detected strong absorption variability in NGC 4507 on time scales between 1.5 and 4 months
- The possibility of absorption by BLR clouds can be ruled out
- A single, universal structure of the absorber is not enough to reproduce the X-ray absorption features of AGNs
- More campaigns will be performed to monitor column density variations on these time scales.

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