Monitoring of the X-ray absorption variability of ESO 362-G018

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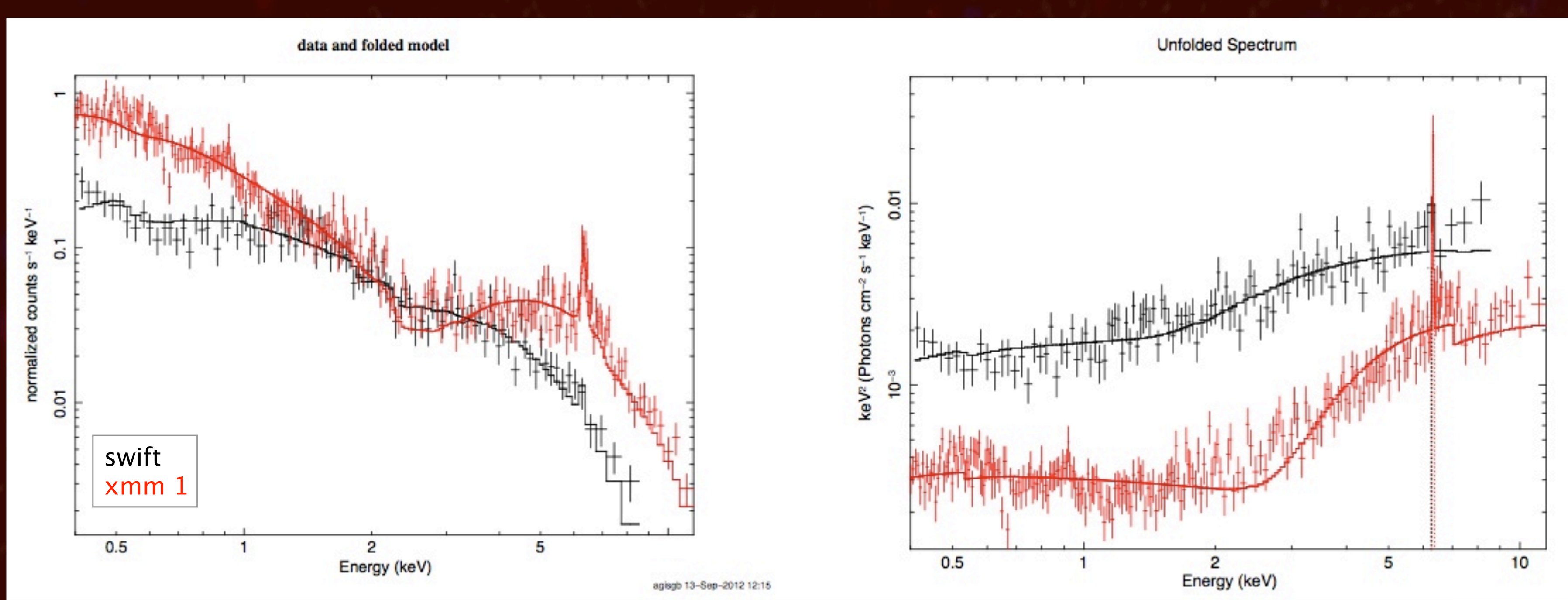
Introduction

In recent years, X-ray absortpion variability has been detected in a growing number of AGN. In the most remarkable cases (e.g. NGC 1365 [1], [2]), the AGN has been seen to switch between Compton-thin and reflection-dominated (i.e. Compton thick) states on timescales as short as 2 days, allowing to put constrains on the size of the primary X-ray source as well as on he absorber(s) location and geometry.
Here we present preliminary results on the X-ray absorption variability in the Seyfert 1 galaxy ESO 362-G018. We analyse previous short Swift and XMM-Newton obtained on November 2005 and January 2006 respectively, as well as new long XMM-Newton and new Chandra pointings obtained in 2010 in the framework of our X-ray observing program of the source (see table).

Obs.number	Observatory	Observation Identifier	Start of obserservations (UT)	Net exposure (ks)	0.5-2 KeV counts	2-10 KeV counts
1	XRT	00035234002	2005-11-26	7.4	1315	1005
2	XMM 1	0312190701	2006-01-28	8.3	3028	2134
3	XMM 2	0610180101	2010-01-29	52.5	80398	43585
4	Chandra 1	11608	2010-05-18	10.1	6502	4240
5	Chandra 2	11609	2010-05-19	10.1	10359	5482
6	Chandra 3	11610	2010-05-21	10.1	5270	2917
7	Chandra 4	11611	2010-05-25	10.1	23923	8917
8	Chandra 5	11612	2010-06-03	10.1	15140	6074

2005/2006 variability

Here we show the dramatic X-ray sepctral variability between the 2005 Swift (black) and 2006 XMM-Newton (red) observations, which were performed two months apart. The two spectra can be described by a simple neutral partial covering model and narrow Fe line. Tha data and the best-fit model are shown in the left panel, while the unfolded spectra are shown in the right one [3].



The spectral variability can be explained by a variation of the X-ray absorber properties. In particular, both the column density and covering fraction appear to be significantly higher in the XMM observation (see table below). The absorbed XMM-Newton state is consistent with a column density of $2x10^{23}cm^2$ covering about 93% of the X-ray source, while the Swift state is consistent with a column density of $0.4x10^{23}cm^2$ and a covering fraction of 0.65.

phabs*zpcfabs*(powerlaw+zgauss)

Obs. Number	Γ^a	n_H $(10^{22}\ cm^{-2})$ ^{b}	Covering Fraction^c	χ^2/ d.o.f
1 (Swift)	$1.94^{+0.12}_{-11}$	$4.20^{+2.21}_{-1.27}$	$0.65^{+0.07}_{-0.08}$	497.56/388=1.2824
2 (XMM1)	$2.23^{+0.05}_{-0.05}$	$19.72^{+2.81}_{-2.42}$	$0.93^{+0.01}_{-0.01}$	"

The drastic changes in spectral shape are well modeled by a simple neutral absorption model. The XMM1 observation is therefore consistent with a **Compton-thin cloud** crossing our line of sigth.

2006/2010 variability

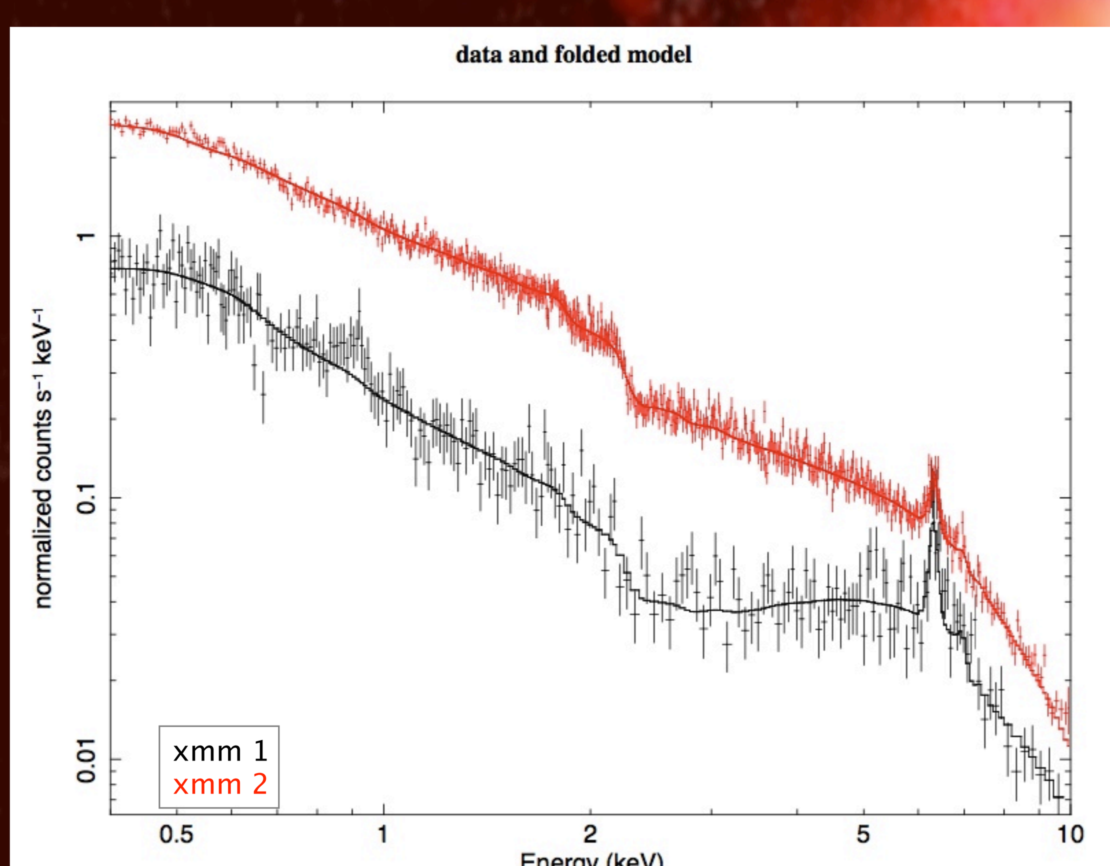
$n_H=19.97^{+2.87}_{-2.46}$
$CvrgFrct=0.92^{+0.01}_{-0.01}$

4 years

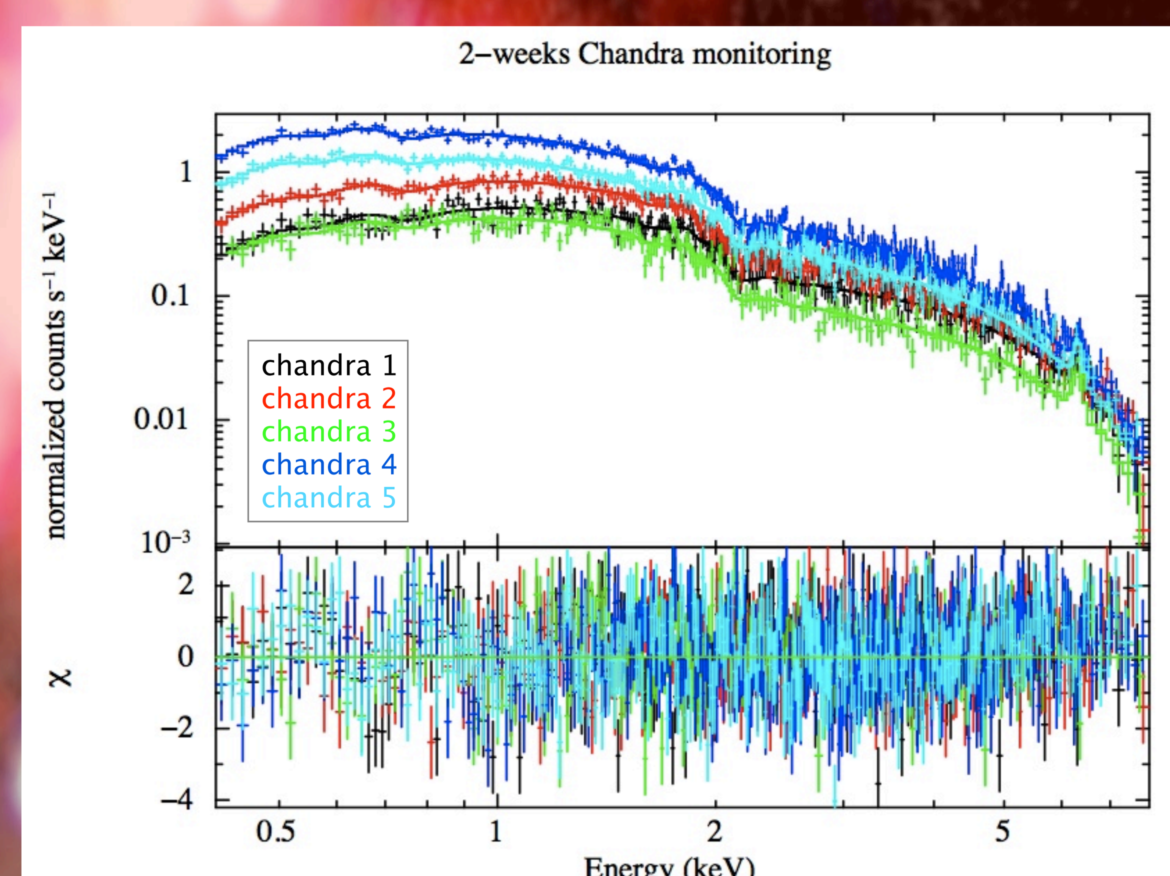
$n_H=5.15^{+1.36}_{-0.91}$
$CvrgFrct=0.68^{+0.01}_{-0.01}$

We observed ESO 362-G018 again with XMM-Newton in 2010 and find that the source has returned to a mildly absorbed state, similar to that seen during the 2005 Swift observation, and much less obscured than during the 2006 XMM-Newton observation (see figure and absorber properties given above).

In order to probe variability timescales shorter than the two months over which the source has been seen to significantly vary in absorption properties, we have monitored the source with 5 Chandra observations spanning 2 weeks in total.



A 2-weeks X-ray monitoring with Chandra



The resulting Chandra spectra, best-fitting models and residuals are shown in the figure. we adopt a simple power-law model with neutral absorption only partially covering the source. Neutral distant reflection (assumed to have constant flux throughout the monitoring period) is modelled with the pexmon model [4], which self-consistently accounts for the reflection continuum and the most important fluorescent emission lines.

The Chandra data also require a non-variable low-energy edge around 0.7 keV, likely the sign of Oxygen absorption in a warm absorber. We mesaure:

phabs*zpcfabs*zedge*(powerlaw+pexmon)

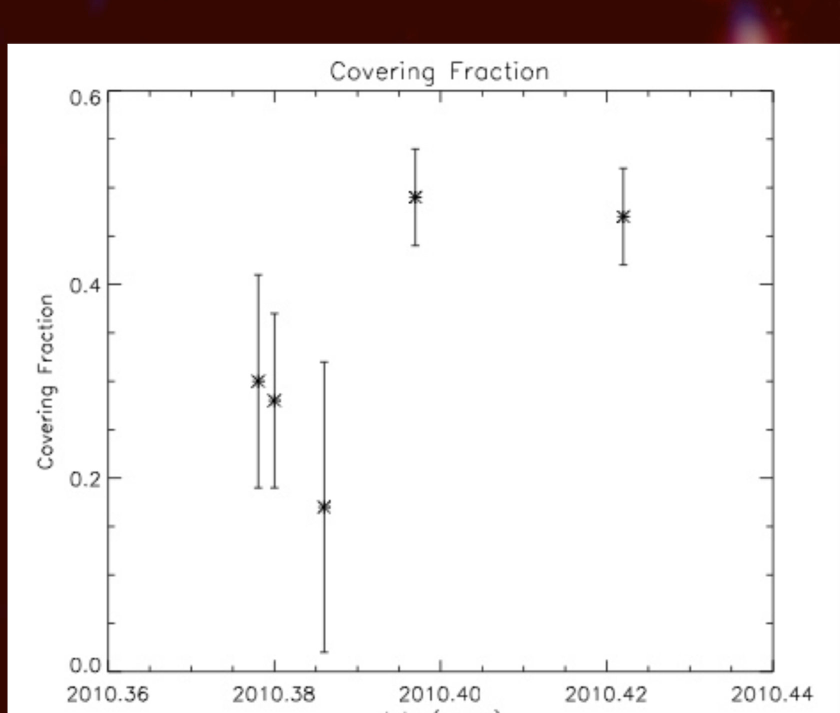
Edge energy=0.72±0.02 KeV with tau=0.35±0.05

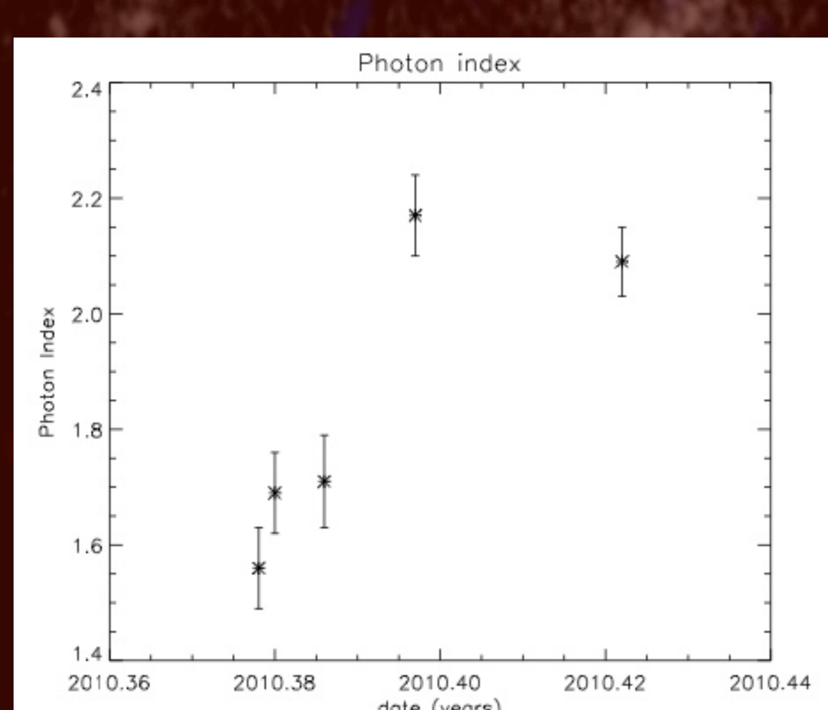
Observation	Date	Photon Index	Covering Fraction^d	2-10 KeV Flux $\left(\frac{erg}{s \cdot cm^2}\right)$
Chandra 1	2010-05-18	$1.56^{+0.07}_{-0.07}$	$0.30^{+0.11}_{-0.11}$	$1.05 \cdot 10^{-11}$
Chandra 2	2010-05-19	$1.69^{+0.07}_{-0.07}$	$0.28^{+0.09}_{-0.09}$	$1.30 \cdot 10^{-11}$
Chandra 3	2010-05-21	$1.71^{+0.08}_{-0.08}$	$0.17^{+0.15}_{-0.15}$	$0.65 \cdot 10^{-11}$
Chandra 4	2010-05-25	$2.17^{+0.07}_{-0.07}$	$0.49^{+0.05}_{-0.05}$	$1.89 \cdot 10^{-11}$
Chandra 5	2010-06-03	$2.09^{+0.06}_{-0.06}$	$0.47^{+0.05}_{-0.05}$	$1.39 \cdot 10^{-11}$

Our initial fits indicate that the absorber column density is consistent with being the same during the whole monitoring period.

We then force a common column density and we measure $N_H = (2.6±0.3)x10^{22}cm^{-2}$. Our results for the photon index, absorber covering fraction, and total 2-10 keV flux for each of the Chandra observations are reported in the table, as well as shown in the figures below.

CONCLUSIONS





→ ESO 362-G018 exhibits a transition from a mildly absorbed to a Compton-thin absorbed state in less than two months, as demonstrated by the November 2005 Swift and January 2006 XMM-Newton observations.

→ Four years later, a long 2010 XMM-Newton observation catches the source in a relatively unabsorbed state, similar to the first Swift observation back in November 2005.

→ A 2-weeks-long monitoring performed with Chandra a few months after the 2010 XMM-Newton observation catches again the source in a relatively unobscured spectral state. The only evidence for absorption variability during the Chandra monitoring is a small increase of the absorber covering fraction from May 21 to May 25 where the covering fraction increses from ~0.2 to ~0.5, although with significant statistical errors (see Figures).

ESO 362-G018 is absorbed by a significant column density (larger than 10^{23} cm^{-2}) only in the January 2006 XMM-Newton observation, i.e. ~ 7% of the time on avearge. Transitions from relatively unobscured to Compton-thin states can in principle occur on timescales ranging from ~15 days to ~2 months. Small variations of the absorber covering fraction are however possible on shorter timescales. This will be further investigated by performing a spectral variability analysis of the long 2010 XMM-Newton observation.

REFERENCES: [1] Risaliti, G., Elvis, M., Fabbiano, G., Baldi, A. & Zezas, A. 2005, ApJ Lett., 623, L93 [2] Risaliti, G., Salvati, M., Elvis, M., et al. 2009, MNRAS, 393, L1 [3] Winter, L. M. & Mushotzky, R. F. 2008, AAS/High Energy Astrophysics Division#10, 10#26.01 [4] Nandra, K. et al. 2007, MNRAS, 382, 194