Unveiling the physics of AGN through X-Ray variability

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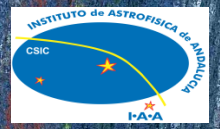
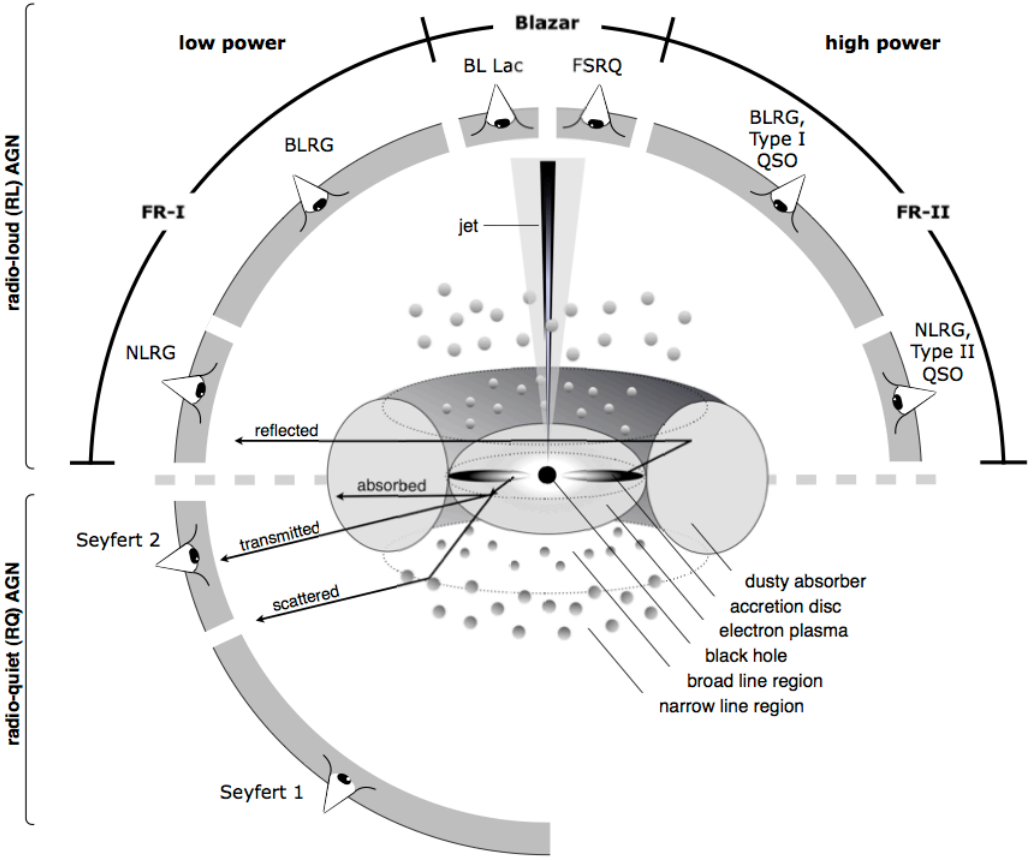


Unveiling the physics behind extreme AGN variability
10-14 July 2017 St. Thomas (U.S. Virgin Islands)

Active Galactic Nuclei (AGN)

- **Unified model of AGN (Antonucci 1993, Urry & Padovani 1995):**
  - **Some subclasses do not fit within the UM (Ho 2008)**

- **Our work: Optically selected (z<0.05):**
  - **Type 1.8, 1.9, and 2 Seyferts (Seyfert 1943)**
  - **Low Ionization Nuclear Emission Line Regions (LINERs, Heckman 1980)**



Credit: Beckmann & Shrader (2012).
Graphic courtesy of Marie-Luise Menzel (MPE)

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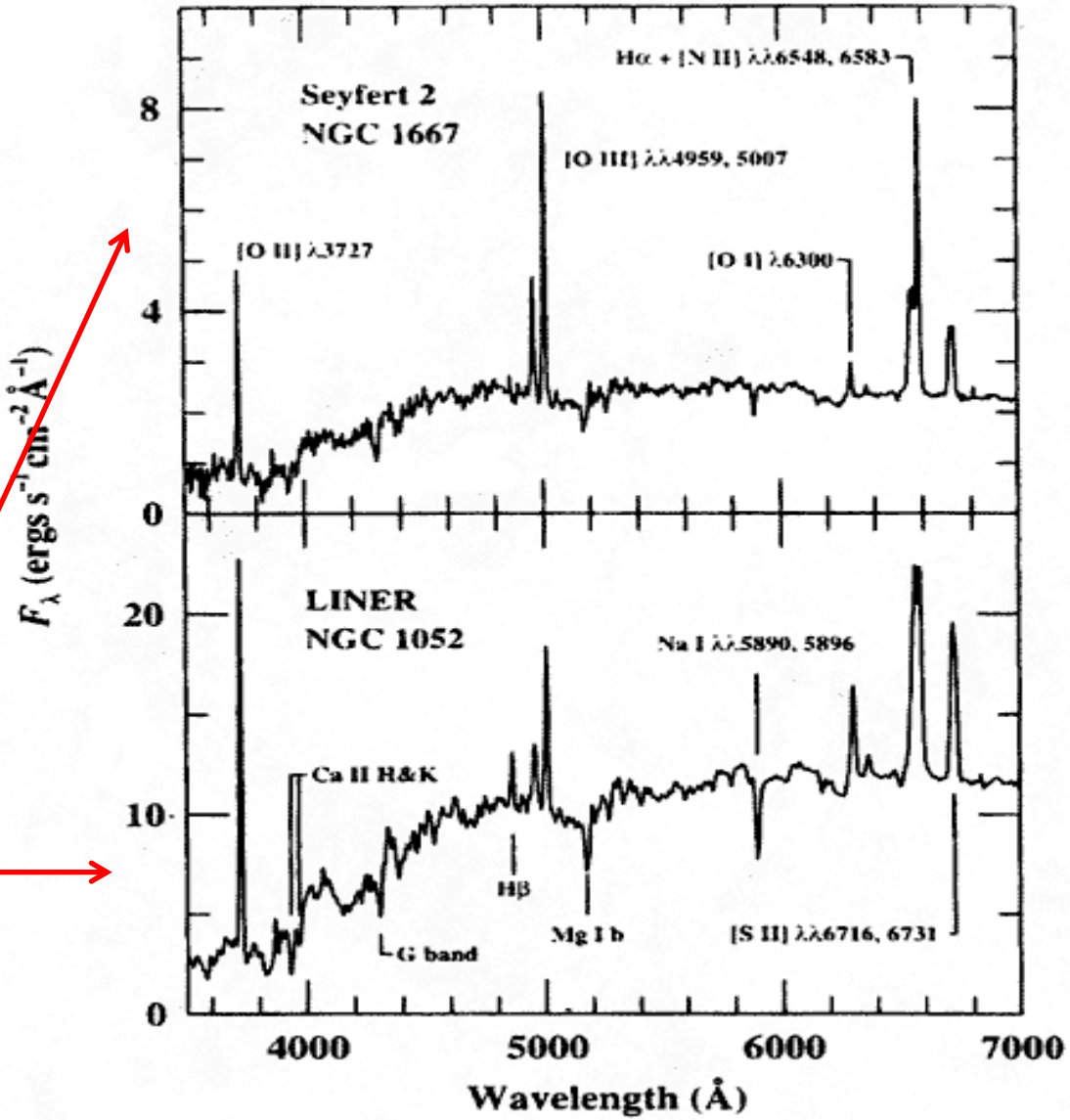


X-rays

- **Produced close to the SMBH**
- **Smaller effect of obscuration than at UV, optical or near-IR frequencies**

Chandra: ***High*** **spatial resolution**

XMM-Newton**: High sensitivity**

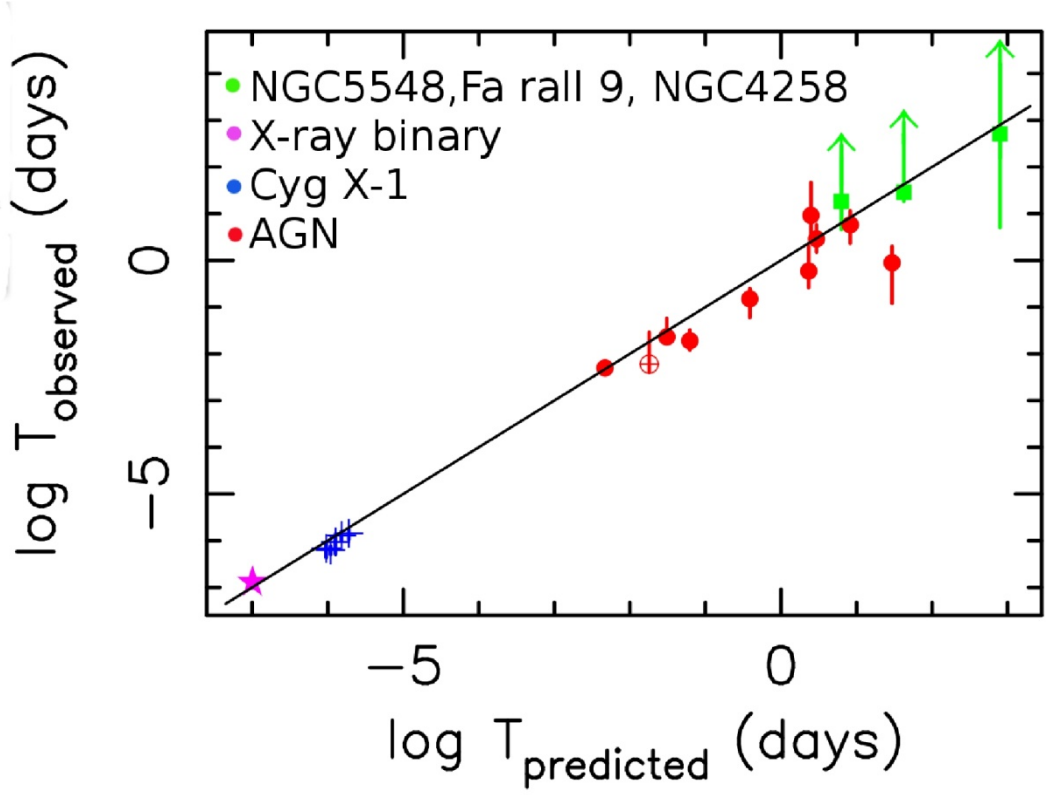
Credits: NASA (left), ESA (right)

Variability

- **It is a general property of AGN (Peterson et al. 1997)**
- **In Seyfert galaxies in the 60s at optical frequencies (e.g. Fitch et al. 1967)**
- **X-ray variability using *OSO-7*, *UHURU* and *Copernicus* in timescales from hours to years**
- **Physical origin related to:**
  - **Variations in the accretion rate (Uttley et al. 2005, McHardy et al. 2010)**
  - **Clouds intersecting the the line of sight (Risaliti 2002, Puccetti et al. 2007)**

Variability

- **LINERs were supposed to be non-variable (Ptak et al. 1998)**
- **At UV frequencies 14 out of 17 varied in timescales from months to years (Maoz et al. 2005)**
- **At X-rays:**
  - **Two out of four vary (Pian et al. 2010)**
  - **Seven out of nine type 1s varied (Younes et al. 2011)**
  - **NGC 4102 varied at soft energies (González-Martín et al. 2011)**
- **McHardy et al. (2006) found a "variability plane" :**



McHardy et al. (2006)

$$\log (T_B) = 2.1 \log (M_{BH}) - 0.98 \log (L_{bol}) - 2.32$$

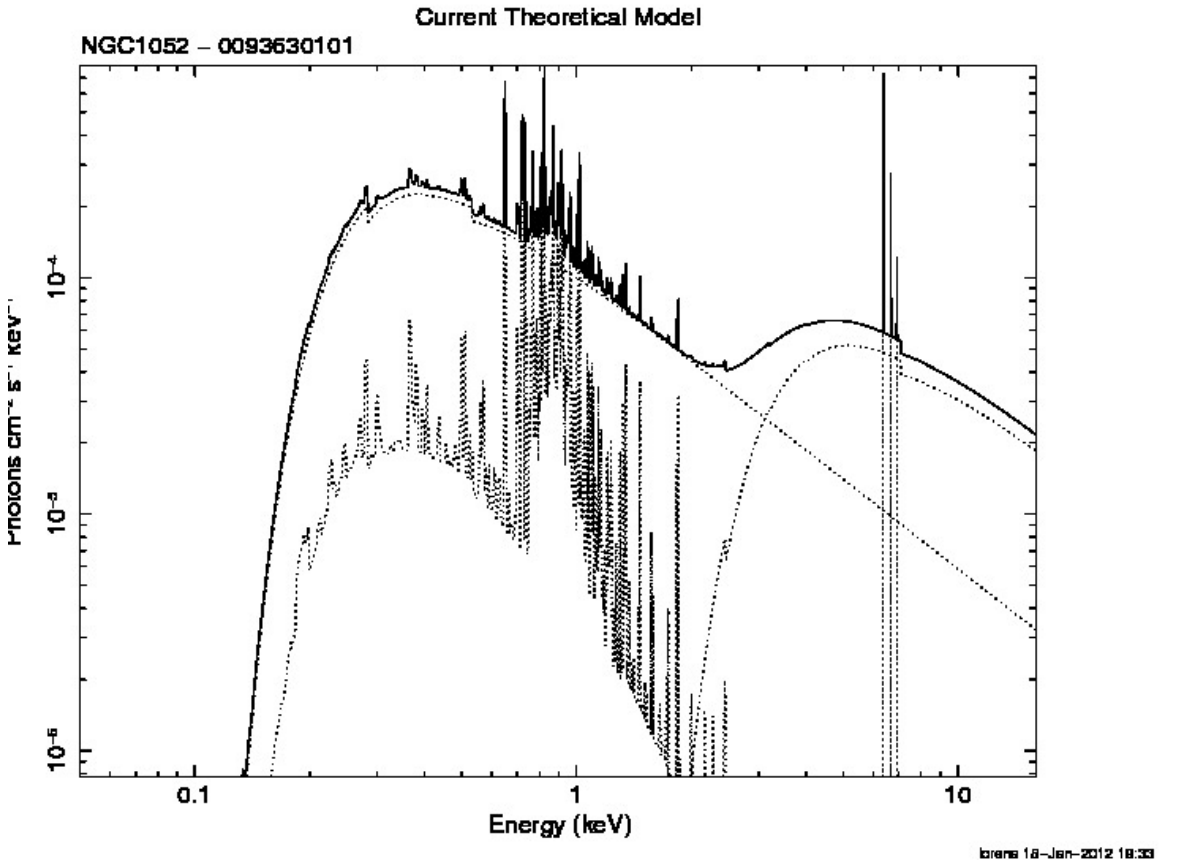
Sample selection

Observations of the same source taken at different dates

from the public archives of *Chandra* and/or *XMM-Newton*

Methodology

- **Individual fit: González-Martín et al. (2009)**
- **Different models are used to fit the spectra :**
  - **ME**
  - **PL**
  - **MEPL**
  - **2PL**
  - **ME2PL**
  - **2ME2PL**



González-Martín et al. (2009)

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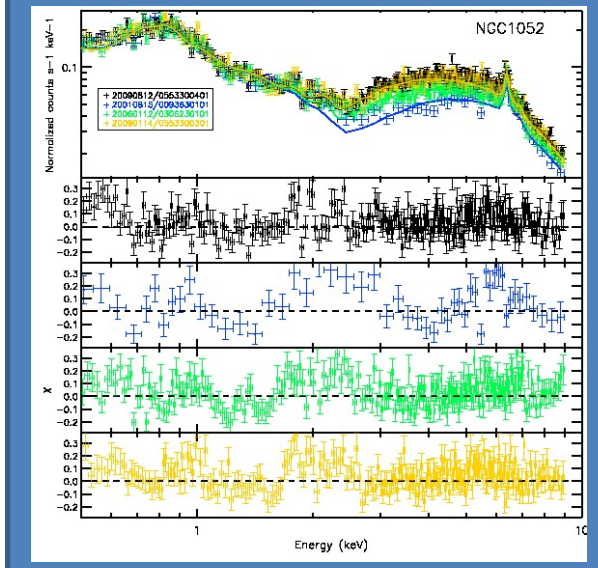
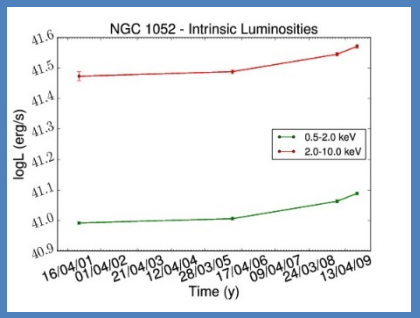
Methodology

- **Simultaneous fit: fit spectra of the same object with the same model**
- **Vary parameters: N_{H1}, N_{H2}, kT, Γ, $Norm_1$, $Norm_2$**
- **We obtain the nature of the observed long-term variations (months/years)**

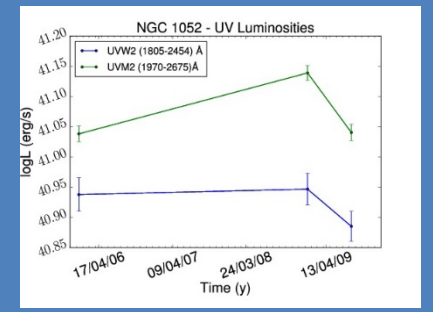
NGC 1052



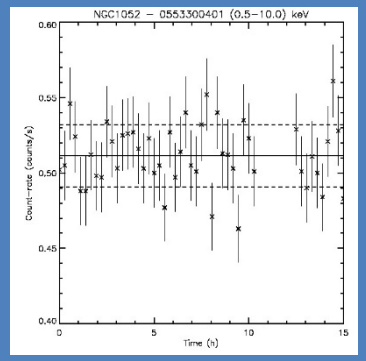
Simultaneous fit



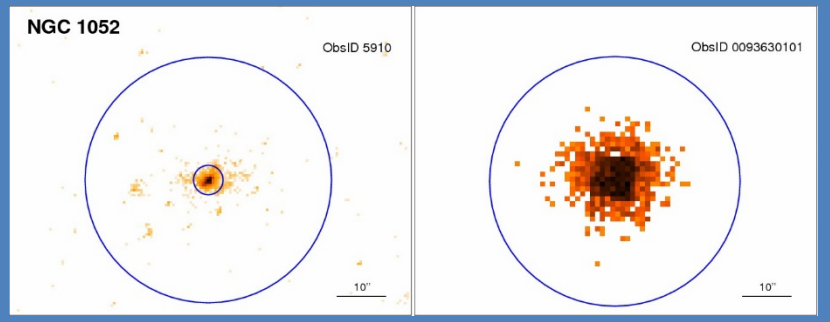
X-ray luminosities



OM UV luminosities



Light curves



Comparison *Chandra-XMM*-Newton data

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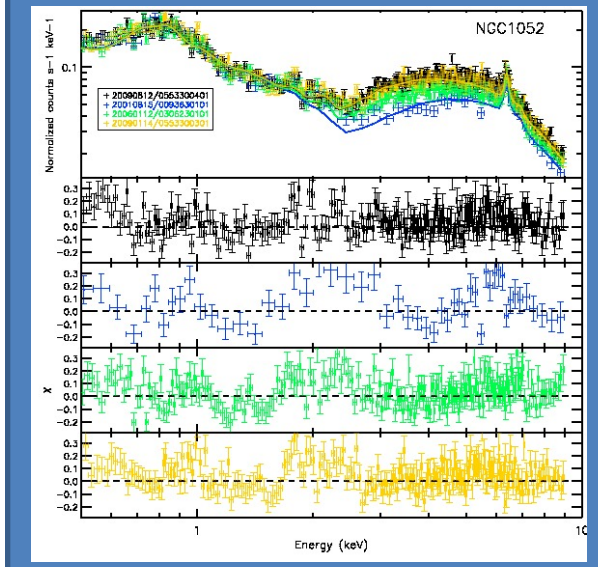
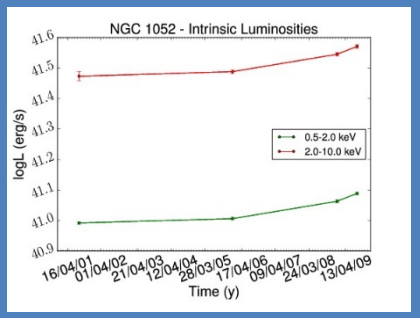
Methodology

- **Additionally:**
  - **Short-term variations from the light curves (days/weeks)**
  - **UV flux variability**
  - **Comparison between *Chandra* and *XMM*-Newton**

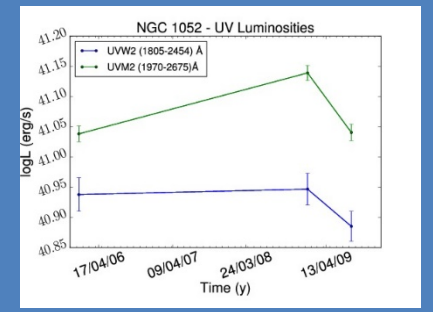
NGC 1052



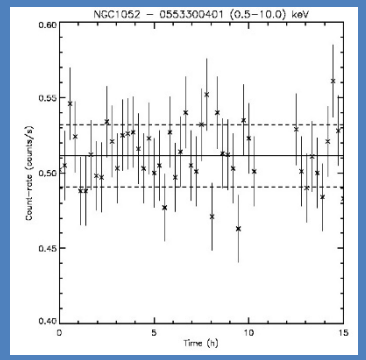
Simultaneous fit



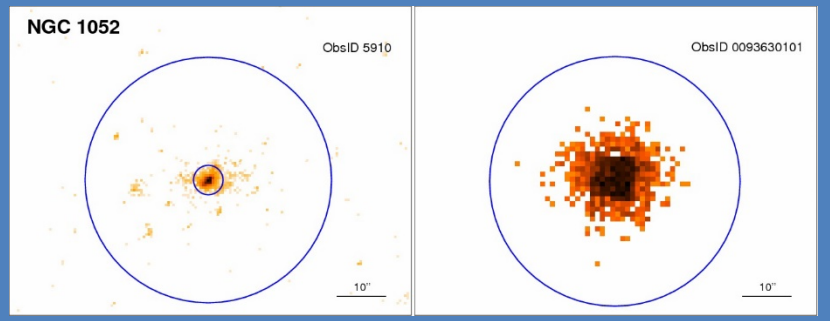
X-ray luminosities



OM UV luminosities



Light curves



Comparison *Chandra*-*XMM*-Newton data

Results: LINERs

- **17 LINERs from the Palomar sample (Ho et al. 1997) or González-Martín et al. (2009):**
  - **Two Compton-thick candidates, i.e. $N_H > 1.5 \times 10^{24}$ cm^{-2}**

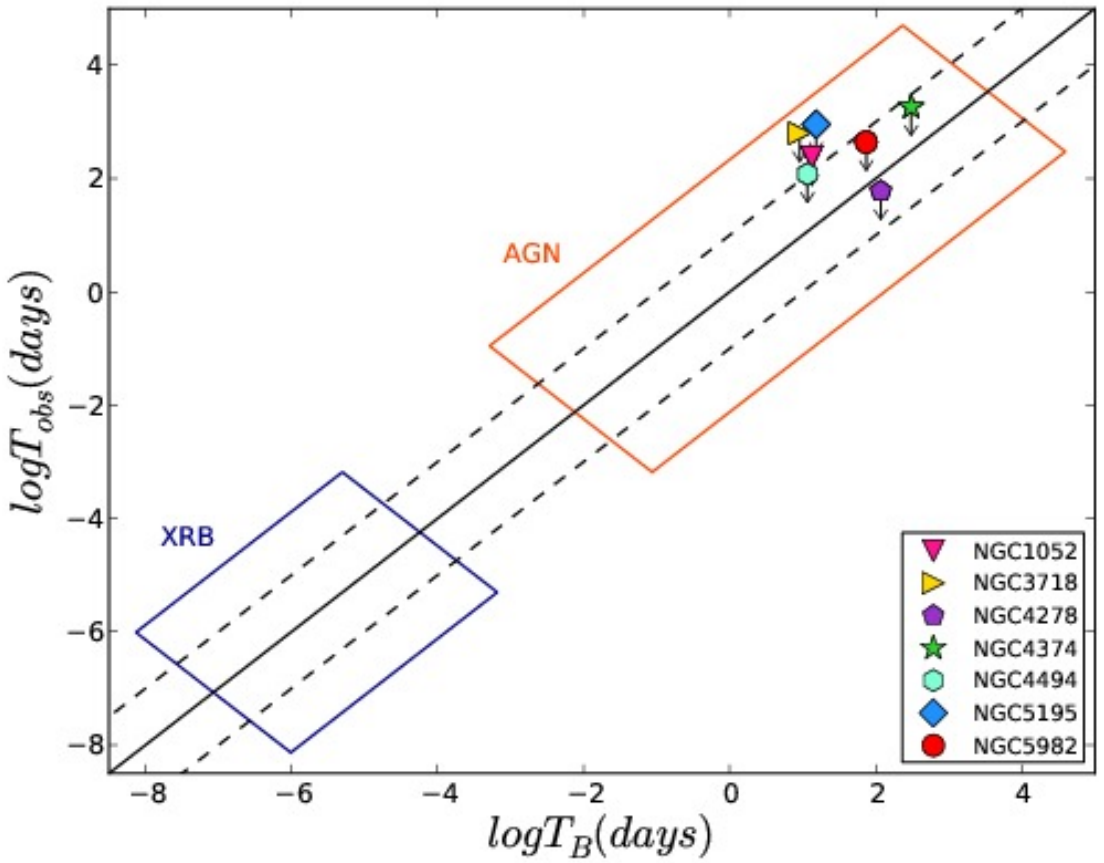
- **No short-term variations**

- **No differences in type 1 / type 2**

Published in Hernández-García et al. (2013, 2014)

Results: LINERs

- **Variability:**
  - **Eight out of 13 variable at X-rays**
  - **Five out of six vary at UV**
  - **11/14 variable (months/years)**
- **Long-term X-ray variability pattern:**
  - **Intrinsic variations:8 cases**
  - **Column density: 1 case**
- **Fit into the "variability plane" (McHardy et al. 2006)**



Hernández-García et al. (2014)

Results: Seyfert 2

- **26 Seyfert 2 from the Véron-Cetty and Véron (2010) catalogue:**
  - **12 Compton-thick candidates**
  - **12 Compton-thin**
  - **Two changing-look candidates (i.e. transitions from Compton-thin to Compton-thick)**

- **No short-term variations**

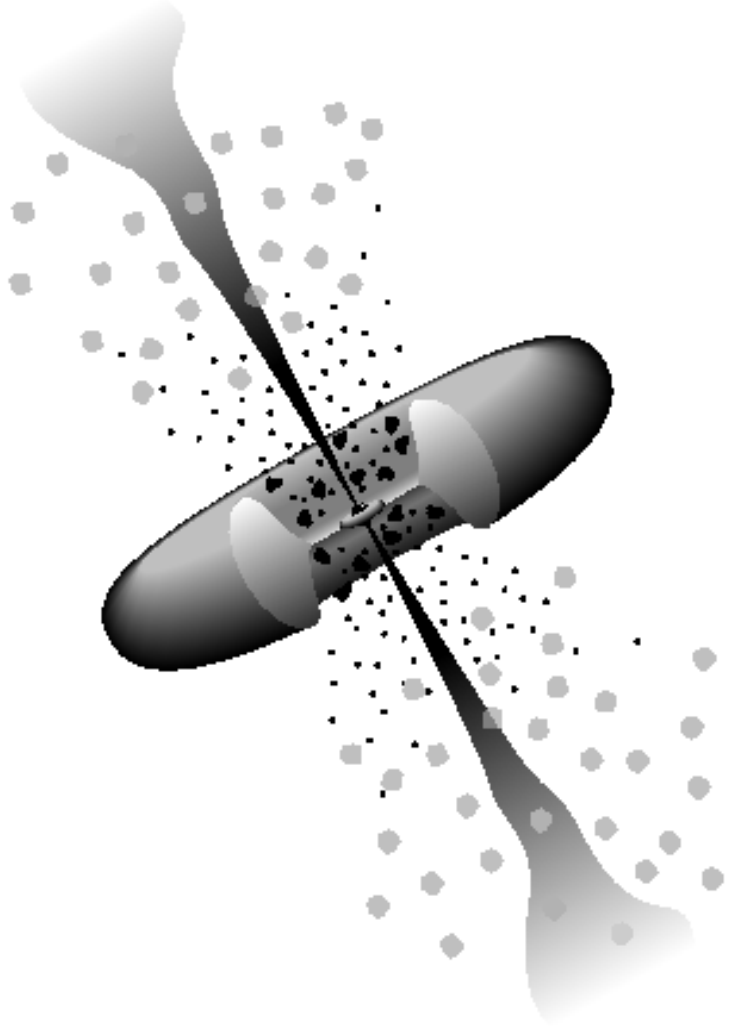
- **No UV variations**

Published in Hernández-García et al. (2015)

Results: Seyfert 2

- **11 out of 25 vary at X-rays**
  - **Nine Compton-thin**
  - **Two changing-look**
  - **None Compton-thick**

- **Long-term X-ray variability pattern:**
  - **Intrinsic variations of the source : 9 cases**
  - **Variations of the column density: 4 cases**



Urry & Padovani (1995)

Results: Seyfert 1.8 and 1.9

- **15 Seyfert 1.8/1.9 from the Véron-Cetty and Véron (2010) catalogue:**
  - **No Compton-thick candidates**
  - **13 Compton-thin**
  - **Two changing-look candidates**

- **No differences in type 1.8/1.9**

Published in Hernández-García et al. (2017)

Results: Seyfert 1.8 and 1.9

- **Variability:**
  - **All the 15 variable in long-term at X-rays**
  - **Six out of eight show short-term X-ray variations**
  - **Seven out of nine vary at UV**

- **Long-term X-ray variability pattern:**
  - **Intrinsic variations of the source : 10 sources**
  - **Variations of the column density: 7 sources**
  - **Variations at soft energies: 5 sources**

Published in Hernández-García et al. (2017)

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Summary of the variations

	LINERs	Seyfert 2	Seyfert 1.8/1.9
Short-term X-ray	No	No	Yes
Long-term X-ray	Yes	Yes	Yes
Variable parameters	$Norm_2$ (N_{H2} in one case)	$Norm_2$, N_{H2}	$Norm_2$, N_{H2}, $Norm_1$
UV	Yes	No	Yes

Summary of the variations

	LINERs	Seyfert 2
Short-term X-ray	No	No
Long-term X-ray	Yes	Yes
Variable parameters	$Norm_2$ (N_{H2} in one case)	$Norm_2$, N_{H2}
UV	Yes	No

Different X-ray luminosities

Same variations independently of the accreation mechanism (Lyubarskii 1997)

Lack of the torus and BLR? (Elitzur & Sloshman 2006)

Comparison published in Hernández-García et al. (2016)

Summary of the variations

	Seyfert 2	Seyfert 1.8/1.9
Short-term X-ray	No	Yes
Long-term X-ray	Yes	Yes
Variable parameters	$Norm_2$, N_{H2}	$Norm_2$, N_{H2}, $Norm_1$
UV	No	Yes

Different N_H

Different behaviour at X-rays and UV

Do not include Seyfert 1.8/1.9 as Seyfert 2!

Comparison published in Hernández-García et al. (2017)

Future work

- **Apply the methodology to samples of type 1 AGN from the Veron catalogue:**
  - **15 Seyfert 1.5 and 8 Seyfert 1.2**
  - **20 Narrow Line Seyfert**

Thanks!