Accretion Disk Winds in Active Galactic Nuclei:

an X-ray View

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"Black hole astrophysics: tales of power and distruction" - Winchester, 18-22/07/2011

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1 Why?

A feedback mechanism between the SMBH and its environments

Understanding the AGN structure and the physics of accretion/ejection on SMBH

2 How?

X-ray observations of AGN with powerful winds: N_H, ξ, L_{ion}, Γ, α_{ox}, ...

Contraints on the wind kinematics, v_{out}

Insights on the wind dynamics, Δv_{out}

3 What?

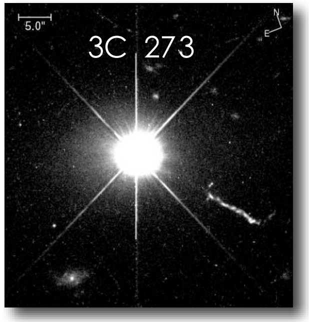
Archival studies: nearby bright sources and distant large samples

A new observational campaign

Theoretical studies

4 And So What?

RADIATIVE FEEDBACK



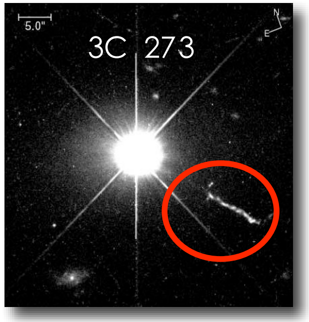
- ***Able to quench the star formation and the cooling flow at the center of ellipticals***

  e.g. Ciotti & Ostriker 2001, Sazonov et al. 2005

- ***It is not enough to reproduce e.g. the M_{BH}-σ relation***

  e.g., Ciotti et al. 2009

MECHANICAL FEEDBACK



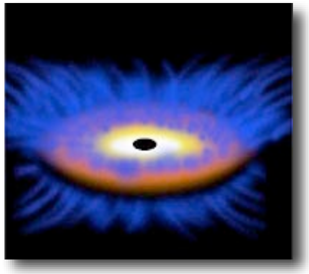
collimated, radiatively bright, relativistic radio jets

- ***Heat the IGM and the ICM, quench the cooling flow in rich Clusters of Galaxies***

  e.g. Fabian et al. 2009, Sanders et al. 2009

- ***Involve ~10% of AGN, and are highly collimated: low global impact for L/L_{Edd} > 0.01***

  e.g., Ciotti et al. 2009



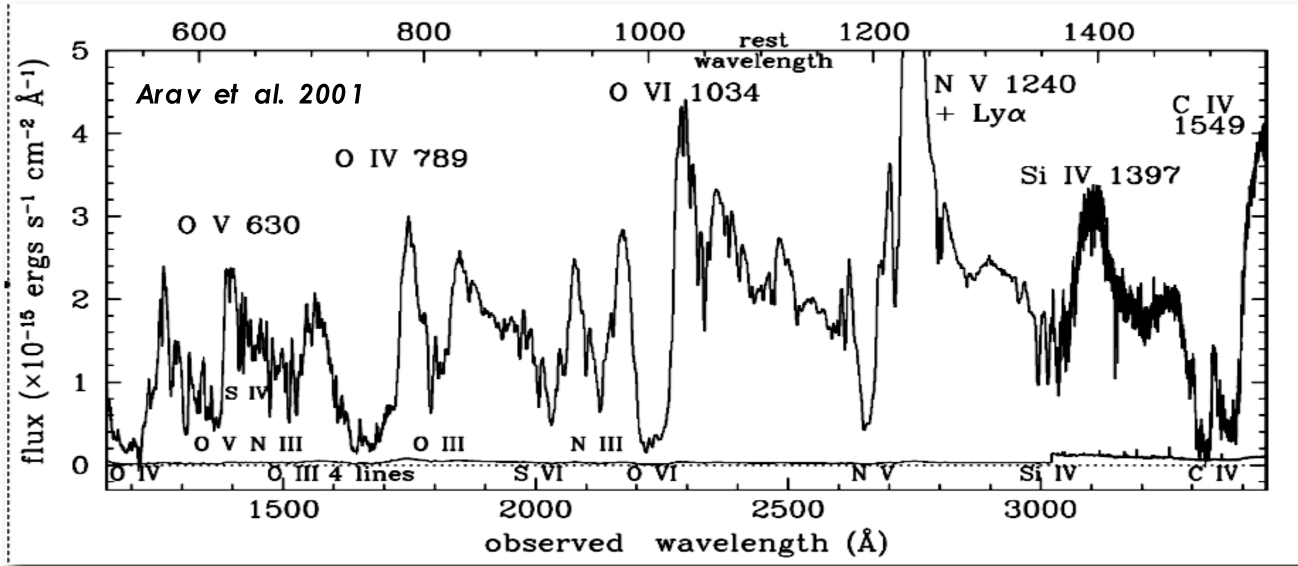
wide angle, radiatively dark, (slow?) massive winds

e.g., Silk & Rees 1998

- ***?***

UV Broad Absorption Lines: BAL QSOs

e.g., Weymann et al. 1981, 1991



~10% of optically selected QSOs

e.g., Hewett & Foltz 2003, Knigge et al. 2008, Gibson et al. 2009

~20% of radio and NIR selected QSOs

e.g., Becker et al. 2000, Shankar et al. 2008

~40% estimated intrinsic fraction

e.g., Allen et al. 2011

FWHM > 2,000 km s^{-1}

- **log ξ ~ 0** erg cm s^{-1}

  e.g., C IV, N V, O VI

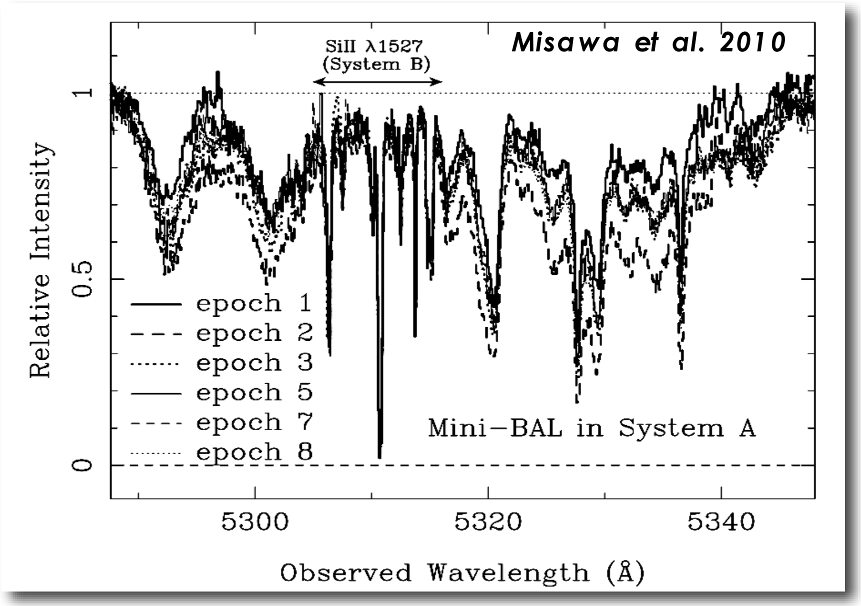
- **logN_H ~ 21-23** cm^{-2}

- **υ_{out} ~ 0.01-0.2** *c*

$$\xi = \frac{L_{ion}}{4\pi n R^2} \propto \frac{n_\gamma}{n_H}$$

UV mini-Broad Absorption Lines: mini-BAL QSOs

e.g., Barlow et al. 1997



~25-50% intrinsic fraction

e.g., Misawa et al. 2007, Ganguly & Brotherton 2008

Systematic studies are still ongoing!

- **log ξ ~ 0** erg cm s^{-1}

  e.g., C IV, N V, O VI

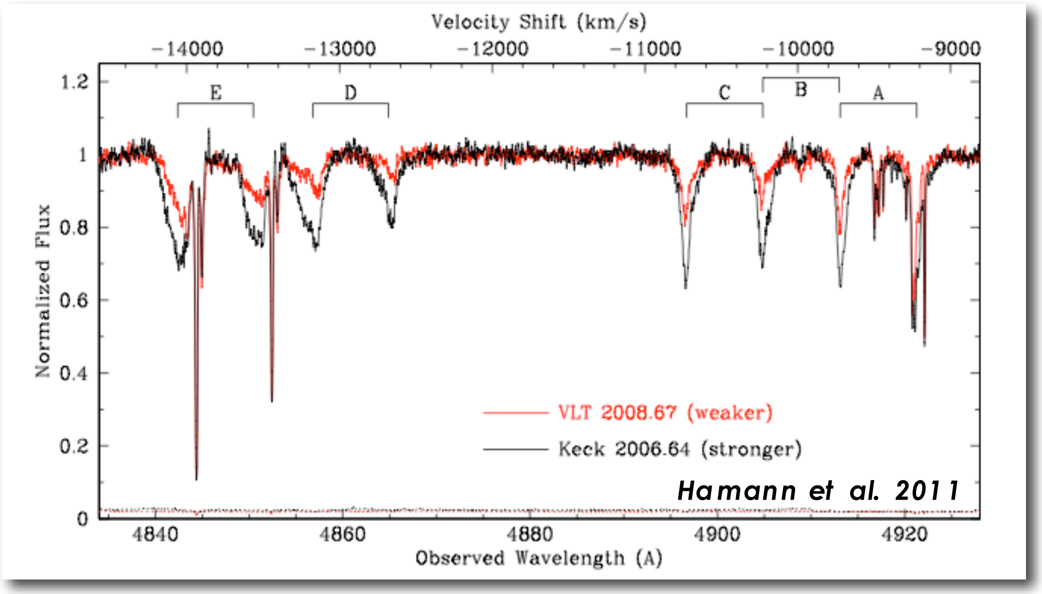
- **logN_H ~ 21-23** cm^{-2}

- **υ_{out} ~ 0.01-0.2** *c*

500 km s^{-1} < FWHM < 2,000 km s^{-1}

UV Narrow Absorption Lines: NAL QSOs

e.g., Ganguly et al. 1999



~25-50% intrinsic fraction

e.g., Crenshaw et al. 2003, Misawa et al. 2007, Ganguly & Brotherton 2008

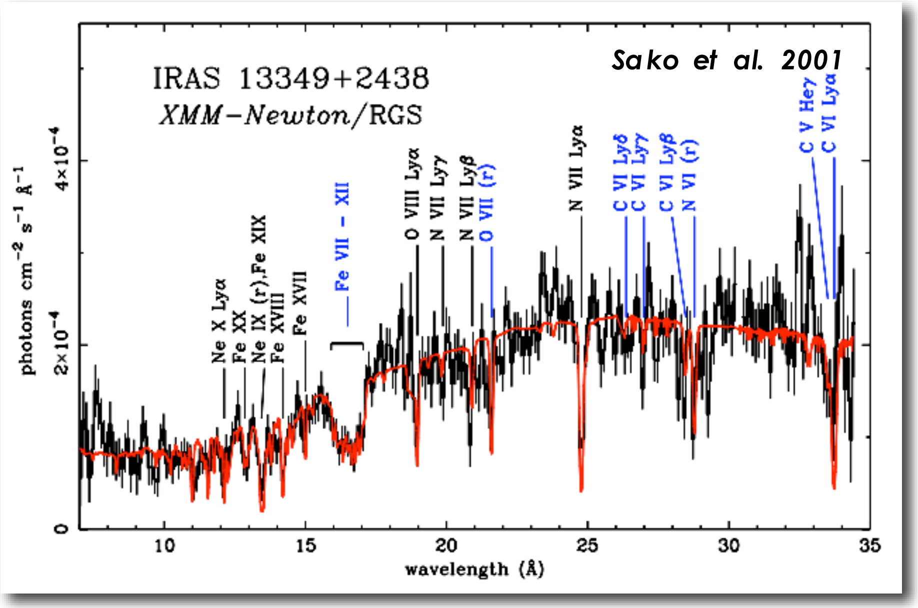
Systematic studies are still ongoing!

- **$\log\xi$ ~ 0** erg cm s^{-1}
  e.g., C IV, N V, O VI
- **$\log N_H$ ~ 21-23** cm^{-2}
- **υ_{out} ~ 0.001-0.2** *c*

FWHM < 500 km s^{-1}

X-ray Warm Absorbers

e.g., Halpern 1984, Reynolds 1997



50% of local AGN

e.g., McKernan et al. 2007

50% of bright QSOs

e.g., Piconcelli et al. 2005

1 to 1 correspondence with low-υ UV NALs

e.g., Crenshaw et al. 2003

➲ **log ξ ~ 0-4** erg cm s^{-1}

e.g., C VI, N VII, O VIII

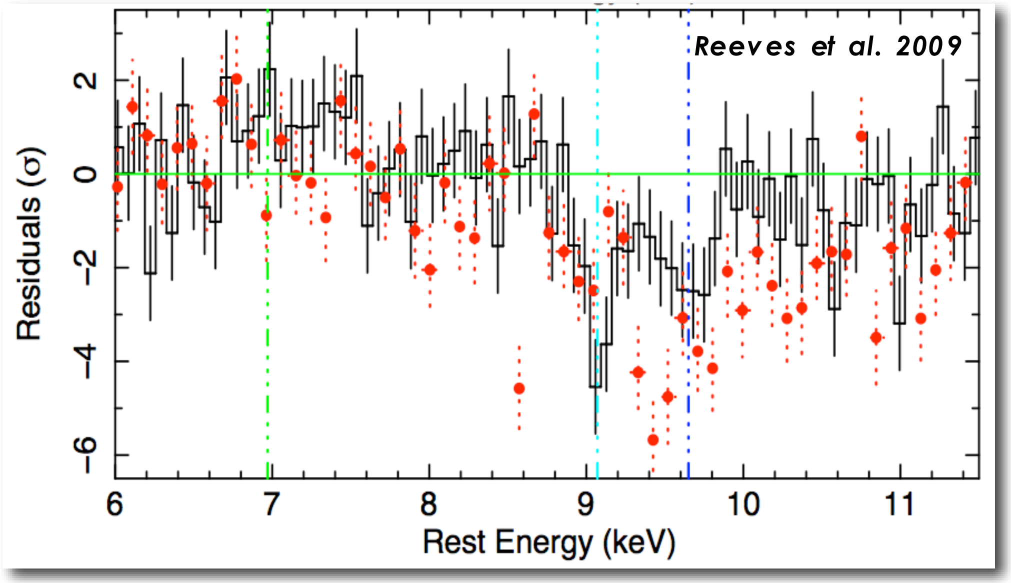
➲ **$\log N_H$ ~ 20-22** cm^{-2}

➲ **υ_{out} ~ 0.001-0.01** *c*

FWHM ~ 300-3,000 km s^{-1}

X-ray high velocity (Ultra Fast) outflows

e.g., Pounds et al. 2003, Cappi 2006, Tombesi et al. 2010



➲ **log ξ ~ 3-5** erg cm s^{-1}

e.g., Fe XXV, Fe XXVI

40% of local bright AGN

Tombesi et al. 2010

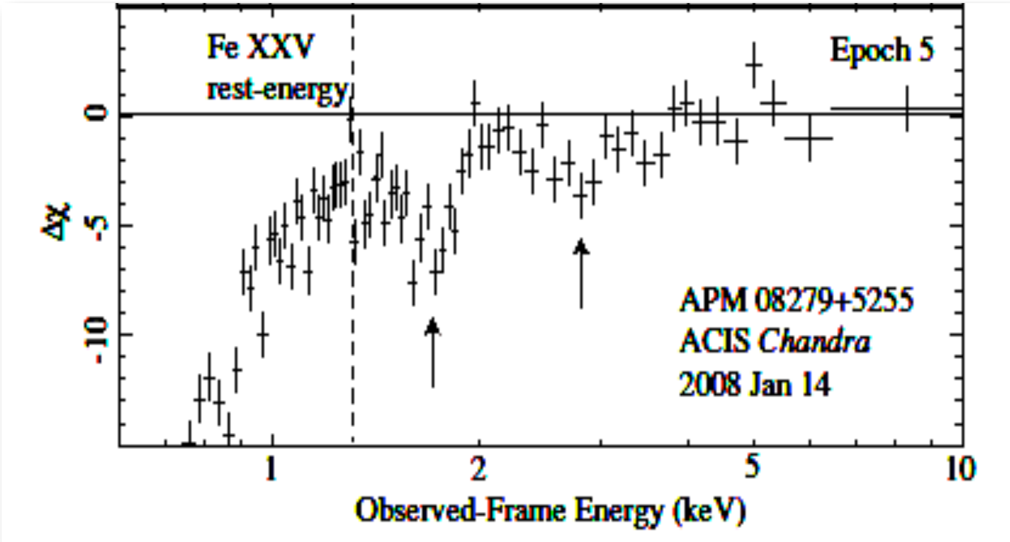
➲ **logN_H ~ 23-24** cm^{-2}

➲ υ_{out} **~ 0.03-0.3** *c*

FWHM ~ 4,000-10,000 km s^{-1}

X-ray Broad Absorption Lines

e.g., Chartas et al. 2002



A handful of BAL and mini-BAL QSOs

e.g., Chartas et al, 2003, 2007, 2009

➲ **log ξ ~ 3-5** erg cm s^{-1}

e.g., Fe XXV, Fe XXVI

➲ **$\log N_H$ ~ 23-24** cm^{-2}

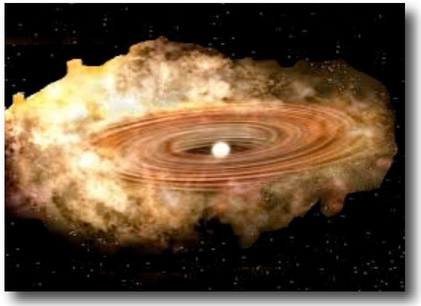
➲ **υ_{out} ~ 0.1-0.4** *c*

FWHM >20,000 km s^{-1}

SMBH Gravity vs Gas, Radiation, or Magnetic Driving

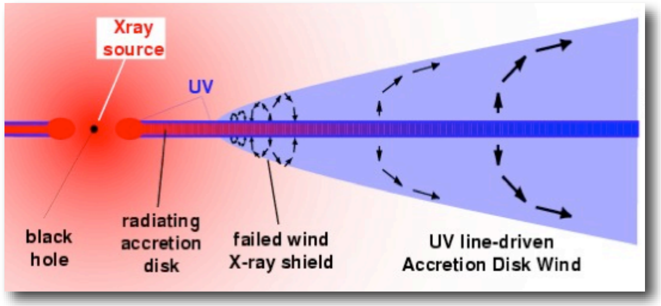
Rude rule of thumb: the fastest the wind terminal velocity, the closest to the SMBH the launching point

Thermal Pressure

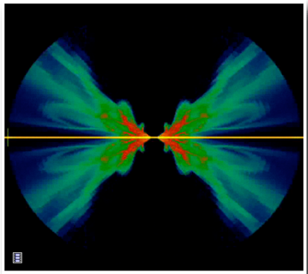


Able to explain **low velocity outflows** as **X-ray warm absorbers** and **low-υ_{out} UV NALs** (e.g., Krolik & Kriss 2001, Chelouche & Netzer 2005)

Radiation Pressure

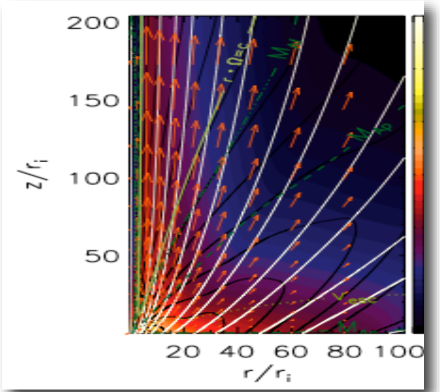


UV line driving: effective **if the wind is shielded** against the central ionizing continuum (e.g., Murray et al. 1995)



A **"shield"** of highly dense gas **naturally arises** in hydrodynamical simulations of highly accreting AGN (e.g., Proga et al. 2000, 2004)

Magnetic Field

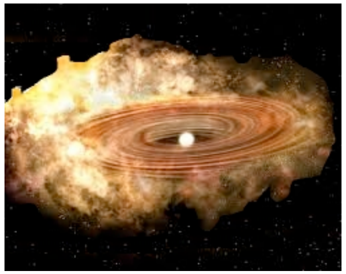


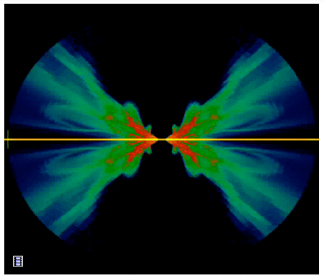
No need for shielding to launch the wind (e.g., Konigl & Kartje 1994, Everett 2005, Fukumura et al. 2010)

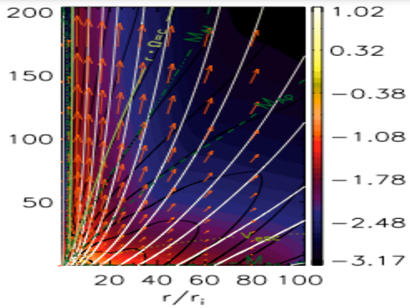
A FEEDBACK MECHANISM BETWEEN THE SMBH AND ITS ENVIRONMENT

How much energy does the wind deposit in the environment?

$$\varepsilon_W \approx \dot{M}_{OUT}\, \upsilon^2_{OUT} / L_{acc}$$







How do accretion disk winds work?

UNDERSTANDING THE AGN STRUCTURE AND THE PHYSICS OF ACCRETION/EJECTION

1 **Why?**

- *A feedback mechanism between the SMBH and its environments*
- *Understanding the AGN structure and the physics of accretion/ejection on SMBH*

2 **How?**

- *X-ray observations of AGN with powerful winds: N_H, ξ, L_{ion}, Γ, α_{ox}, ...*
- *Contraints on the wind kinematics, υ_{out}*
  Insights on the wind dynamics, $\Delta\upsilon_{out}$

3 **What?**

- *Archival studies: nearby bright sources and distant large samples*
- *A new observational campaign*
- *Theoretical studies*

4 **And So What?**

Early X-ray observations of AGN winds

- **Green et al. 1995 ApJ 450, 51** RASS x LBQS *First systematic survey*

BAL QSOs are X-ray weak : 1/37 BAL QSO detected

optical to X-ray spectral index $$\alpha_{ox} = \frac{\log(f_{2keV} / f_{2500\text{A}})}{\log(\nu_{2keV} / \nu_{2500\text{A}})} < -2$$

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Significant absorption, typical underlying intrinsic continuum

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First spectra of BAL and mini-BAL QSOs

Complex, variable absorption and typical underlying intrinsic continuum

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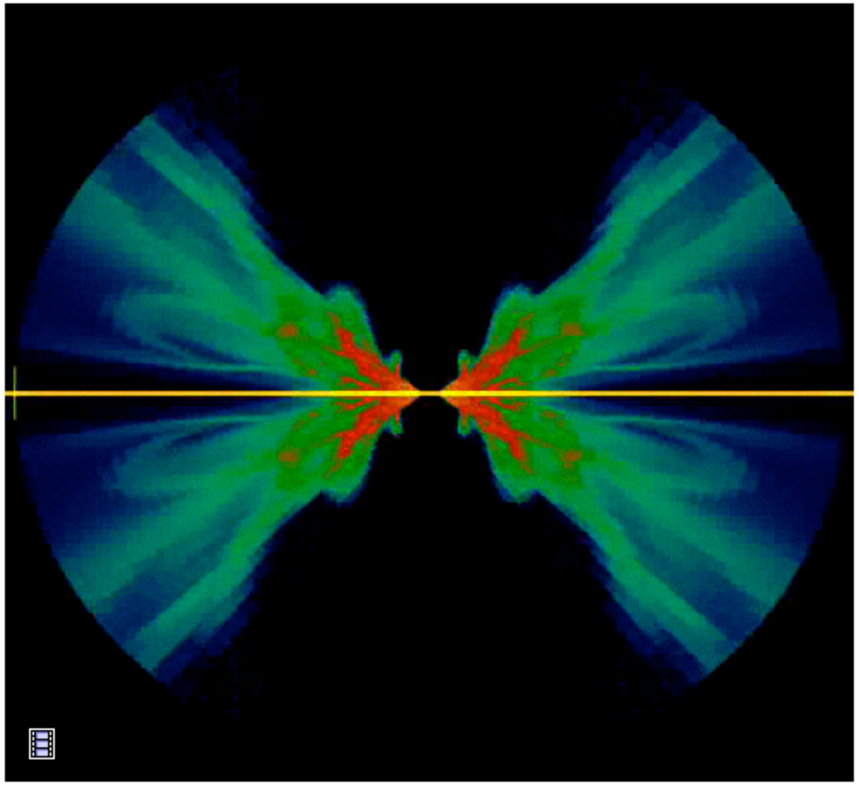
- **Gallagher et al. 2006 ApJ 644, 709** — Chandra x LBQS — *22/35 BAL QSO detected, a few counts each: Hardness Ratio analysis*

Inferred absorbing column density $N_H \sim 10^{22} - 5 \times 10^{23}$ cm^{-2}

X-ray weakness: confirmed

Early X-ray observations of AGN winds: results

- BAL QSO are soft X-ray weak
  - most probably because of absorption
    - the absorption is probably complex (partially covering and/or ionized)
    - hints for absorption variability
- the intrinsic continuum is typical of RQ type 1 AGN



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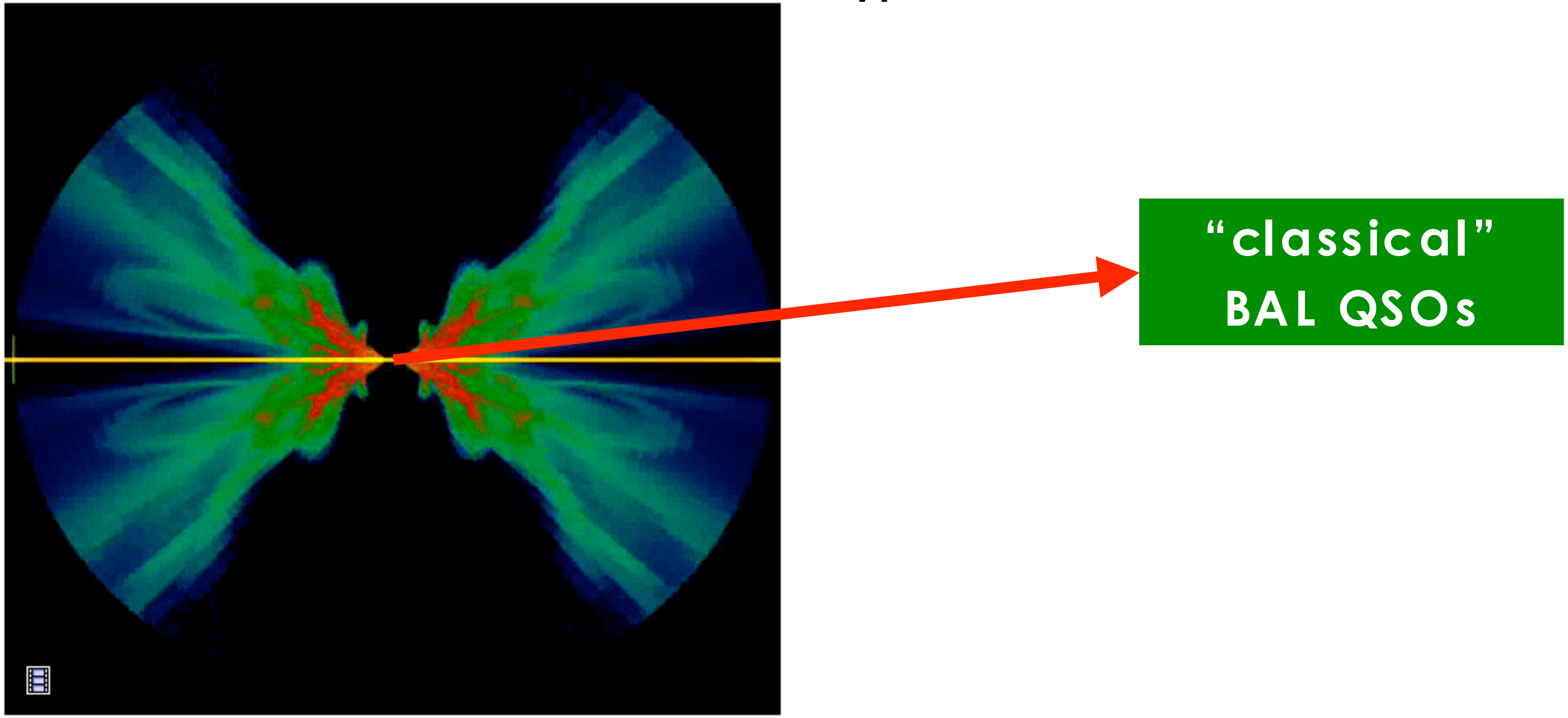

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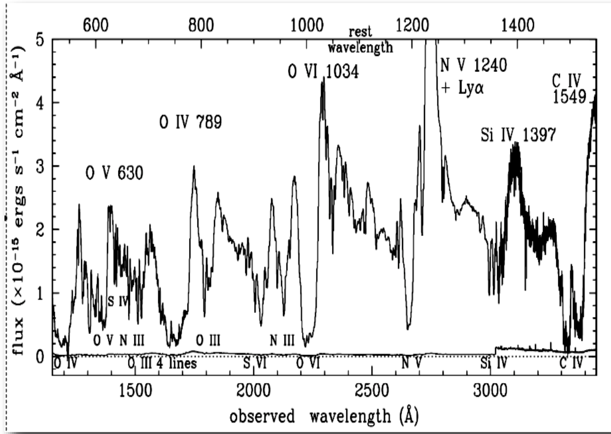
Research Strategy

X-ray observations of BAL QSOs are challenging:



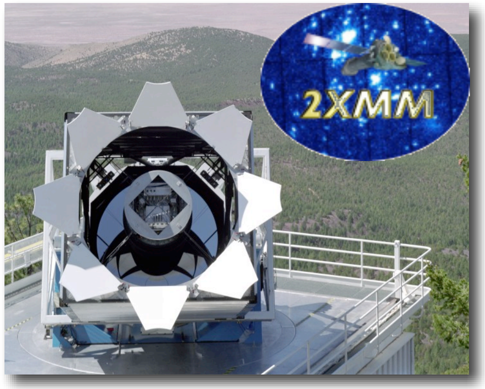
C IV λ1549: 1.7 < z < 4.4 from ground

X-ray Weak: $\alpha_{ox} < -2$

- ***large samples at <z>~2 : statistical studies***
- ***substantial samples at <z>~0.5 : detailed spectral analyses***
- ***the best candidate at z<0.1 : time resolved spectral analyses***

- Archival studies — *The SDSS/2XMM and PG/XMM samples*
- Serendipitous studies — *The NAL QSO sample*
- The new observational campaign — *PG 1126-041: XMM-Newton AO7 & AO8*
- Theoretical analyses — *Synthetic line profiles and disk wind studies*

The archival SDSS/2XMM sample and the NAL QSO sample



➲ **Giustini et al. 2008 A&A 491, 425**

"On the absorption of X-ray bright BAL QSOs"

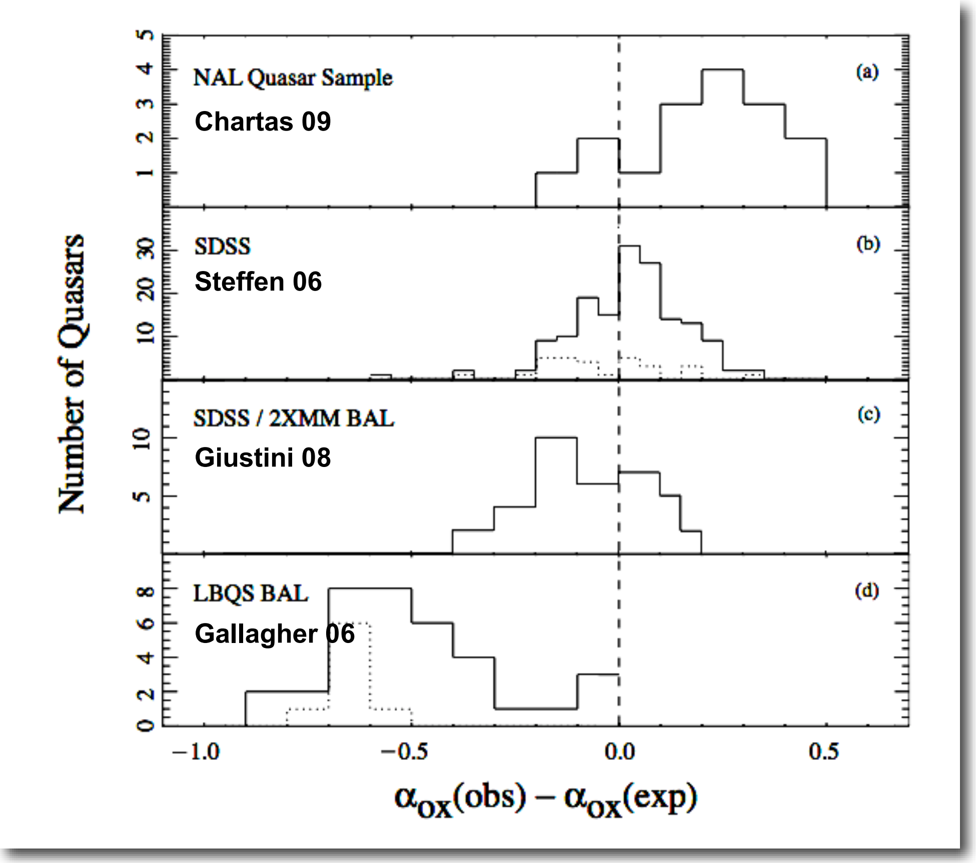
- **SDSS × 2XMM** : large sample of distant (1< z <4) sources
- **54 BAL and mini-BAL QSOs** : X-ray spectral and Hardness ratio analyses, and UV/X-ray photometry : N_H, Γ, α_{ox}, υ_{UV}, ...

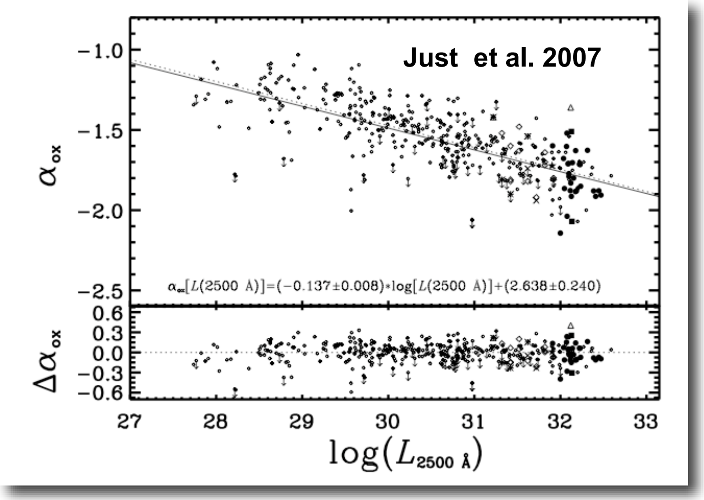
➲ **Chartas et al. 2009 NewAR 53, 128**

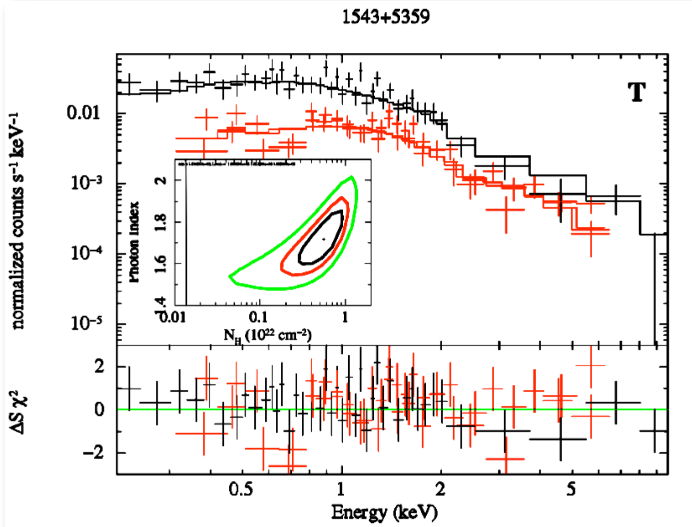
"High velocity outflows in NAL QSOs"

- **16** QSOs with intrinsic high velocity NALs *from Misawa et al. 2007*
- **(XMM + Suzaku) × (Keck + VLT)** : 2 < z < 3

The archival SDSS/2XMM sample and the NAL QSO sample



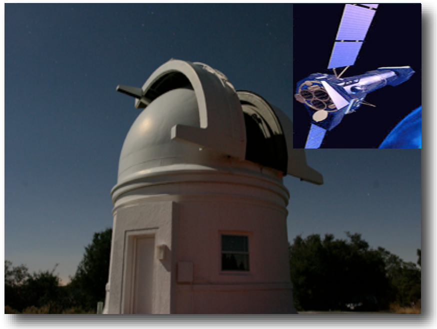




X-ray weakness

- *Typical continuum < Γ > ~ 1.9*
- *No evolution of properties with redshift*
- *Cold X-ray absorption proportional to the X-ray weakness*

The archival PG/XMM Sample



➲ **Giustini et al. 2011, in preparation**

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- **XMM × PG Catalog**: 15 UV bright AGN at <z>~0.5, 32 exposures
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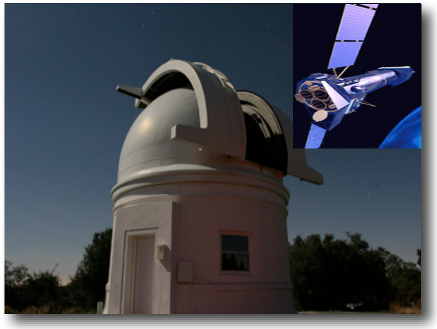

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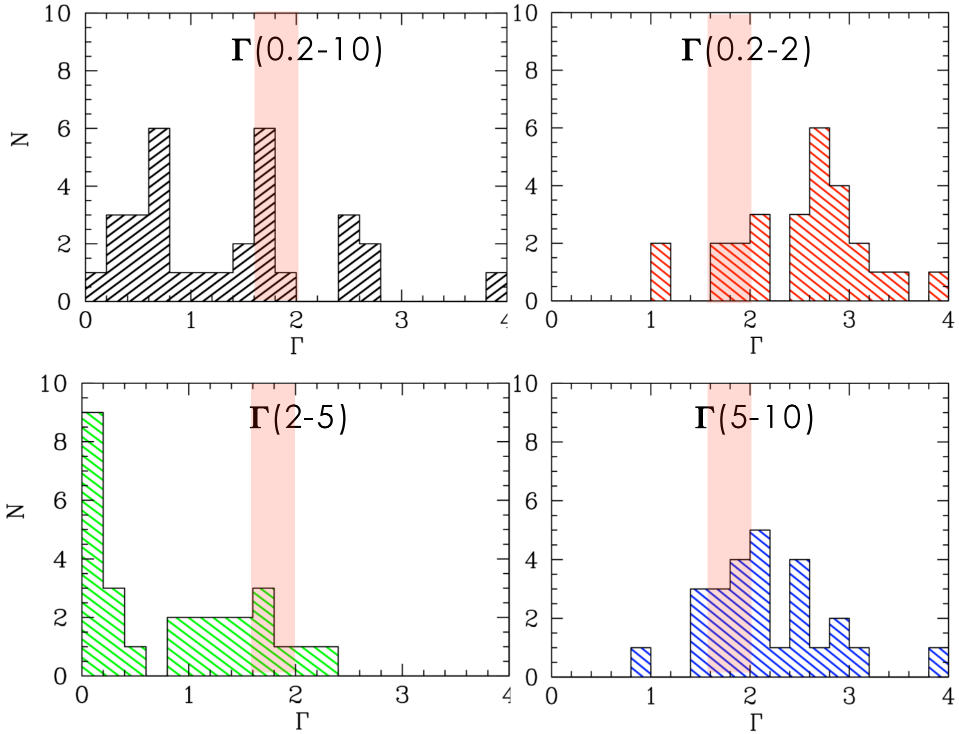

Only 2/14 sources show Γ(2-5)> Γ(5-10) : strong reflection is (most likely) not the dominant cause of the observed broad band flatness.

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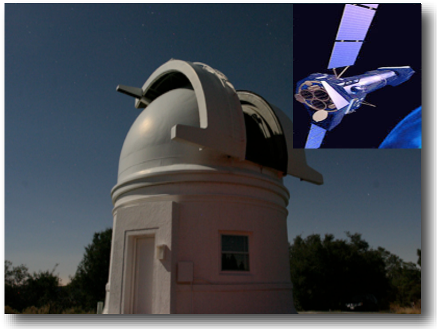

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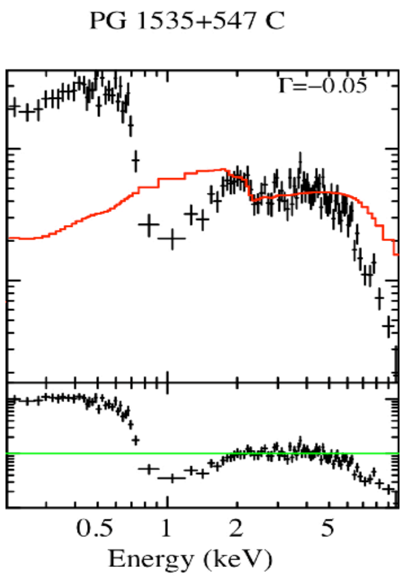

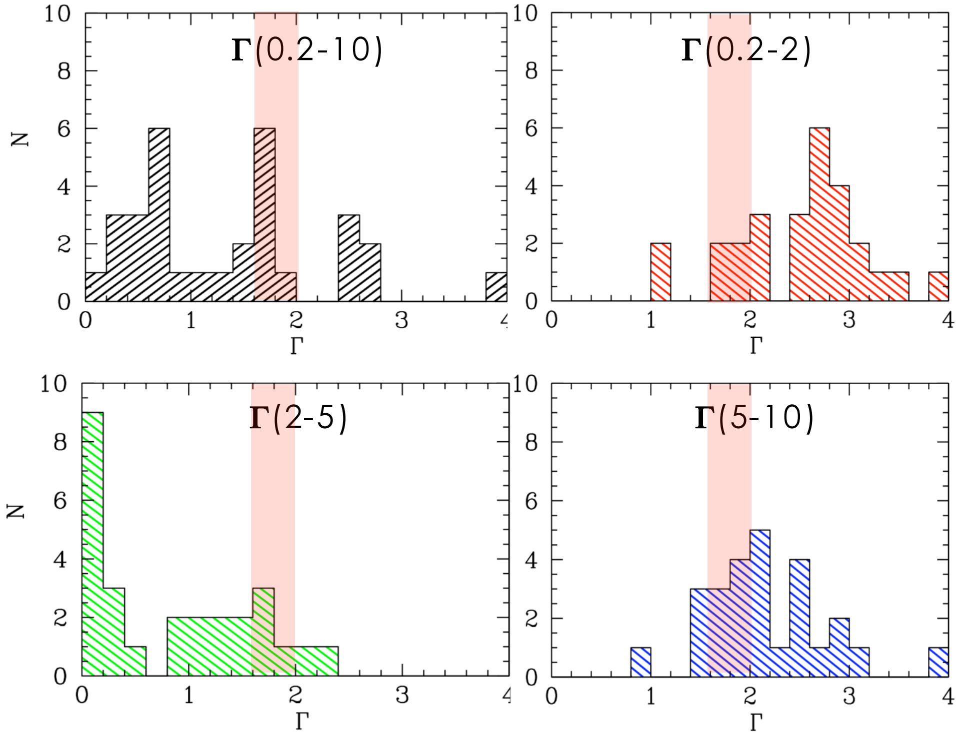

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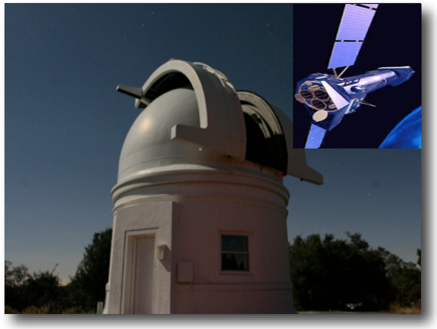

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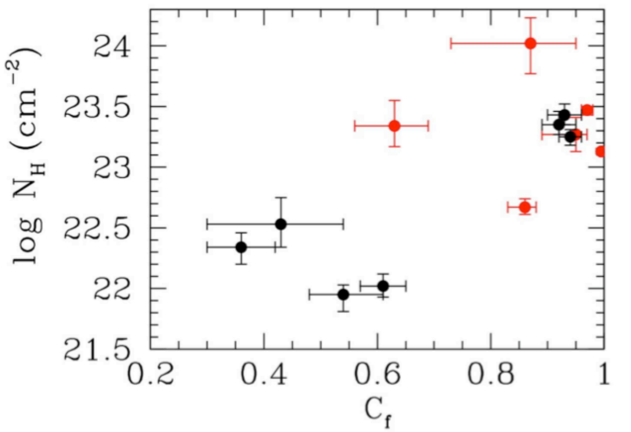
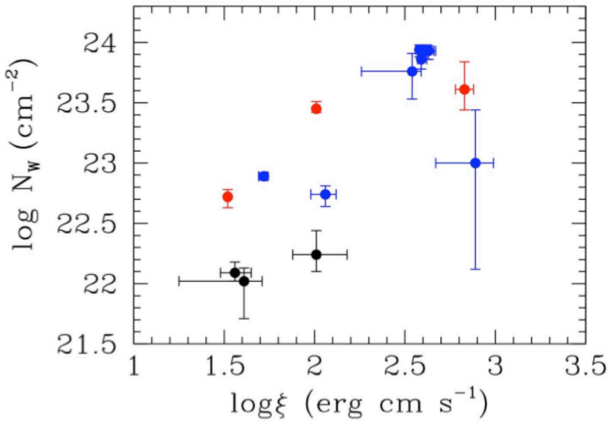
  N_H~10^{22-24} cm^{-2} if the absorber is partially covering or ionized, in a half of the exposures





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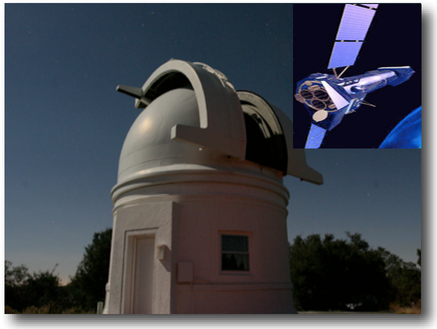

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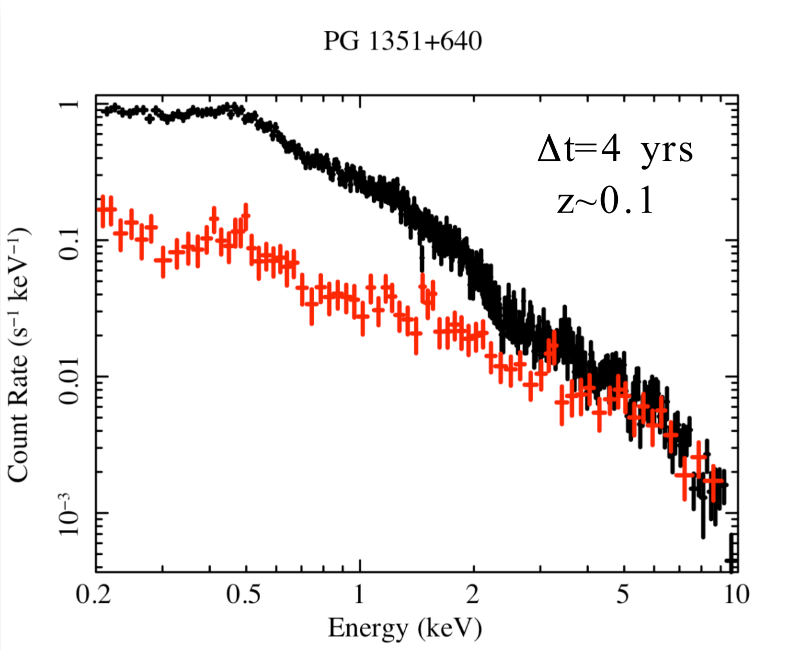
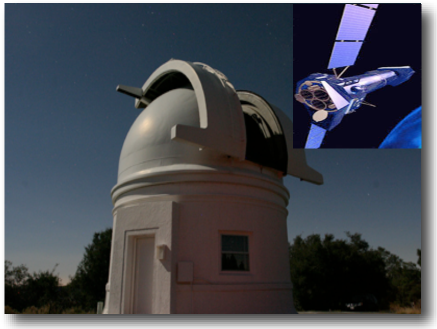
- ***time-resolved analysis: strong spectral variability***

  on time scales of years





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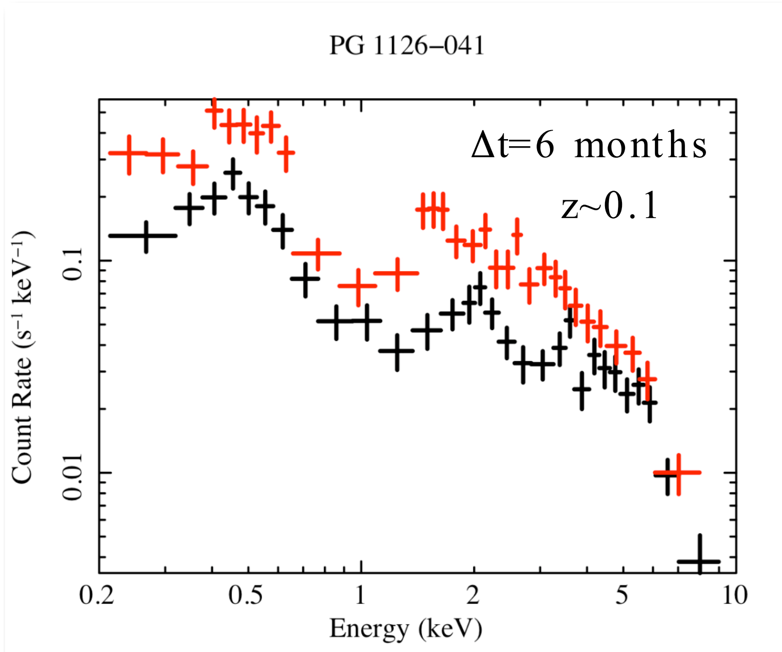

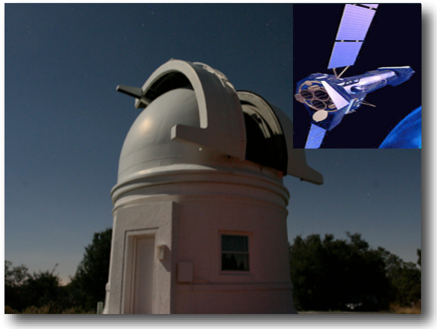

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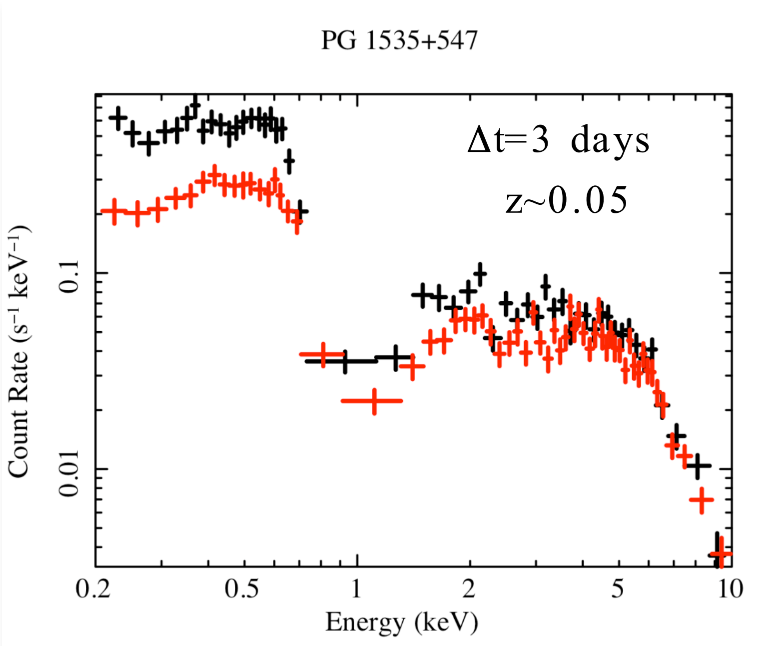
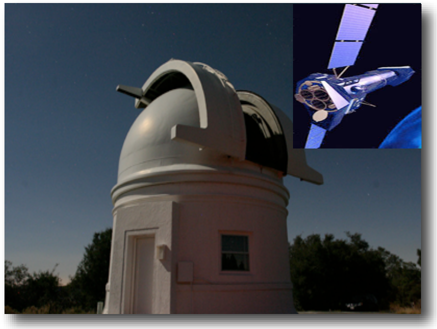


The archival PG/XMM Sample



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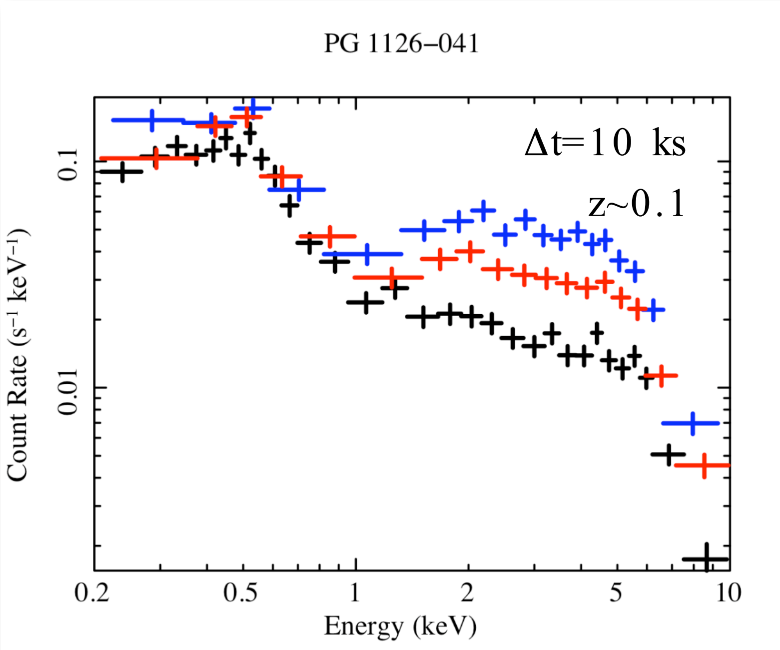

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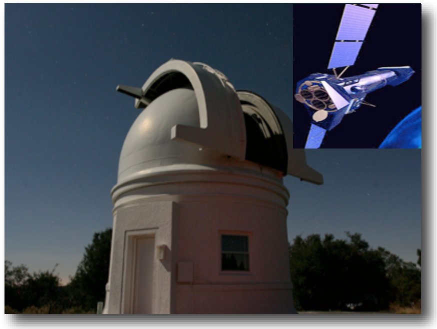

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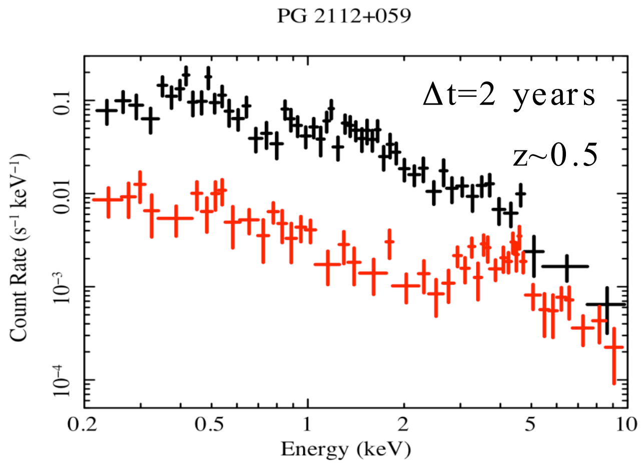
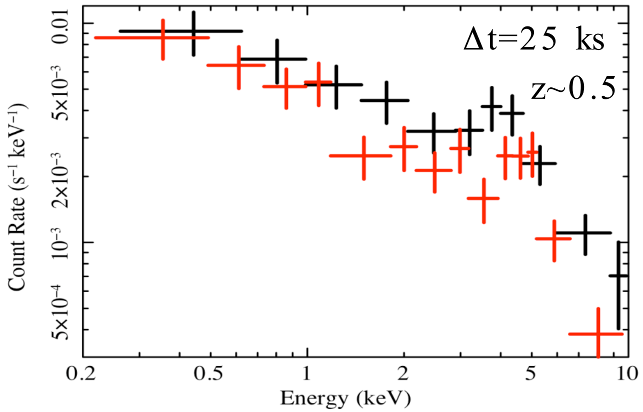
- ***time-resolved analysis: strong spectral variability***

  on time scales of years, months, days, hours

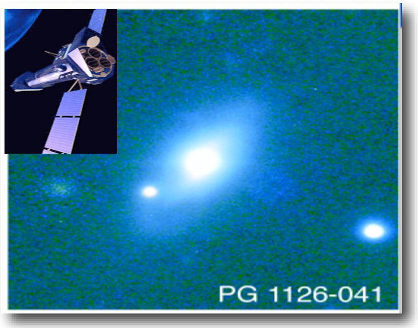
  on multiple time scales

➲ ***α_{ox} is variable!***





The new observational campaign on PG 1126-041



- $z=0.062$
- $M_{BH} \sim 1.2 \times 10^{8}\ M_{\odot}$
- $r_g \sim 1.8 \times 10^{13}$ cm
- $t_L \sim 600$ s
- $L_{BOL} \sim 10^{12}\ L_{\odot}$
- $M_{acc} \sim 0.7\ M_{\odot}/yr$
- $L/L_{Edd} \sim 0.26$
- $\upsilon_{UV} \sim 5{,}000$ km/s

➲ **Giustini et al. 2011, A&A submitted**

"Variable X-ray absorption in the mini-BAL QSO PG 1126-041"

XMM Archive: 33 (28) ks, December 2004 (PI: N. Schartel)

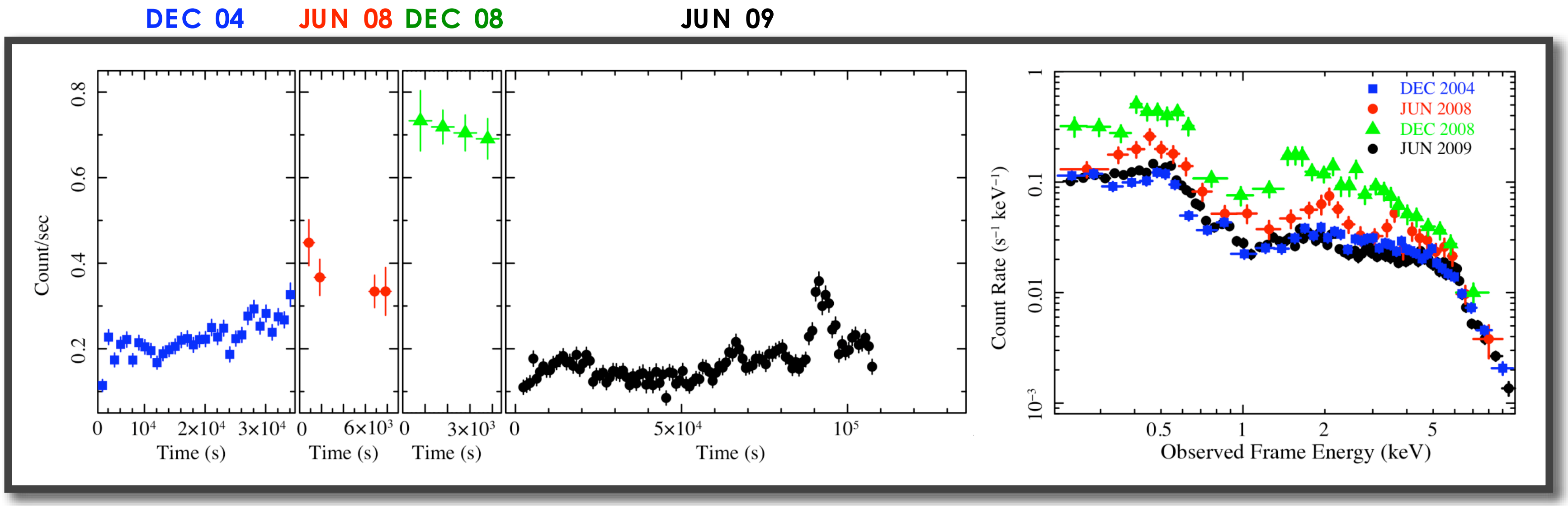
XMM AO-7: 31 (3) ks, June 2008 (PI: M. Giustini)

XMM AO-7: 12 (4) ks, December 2008 (PI: M. Giustini)

XMM AO-8: 134 (92) ks, June 2009 (PI: M. Giustini)

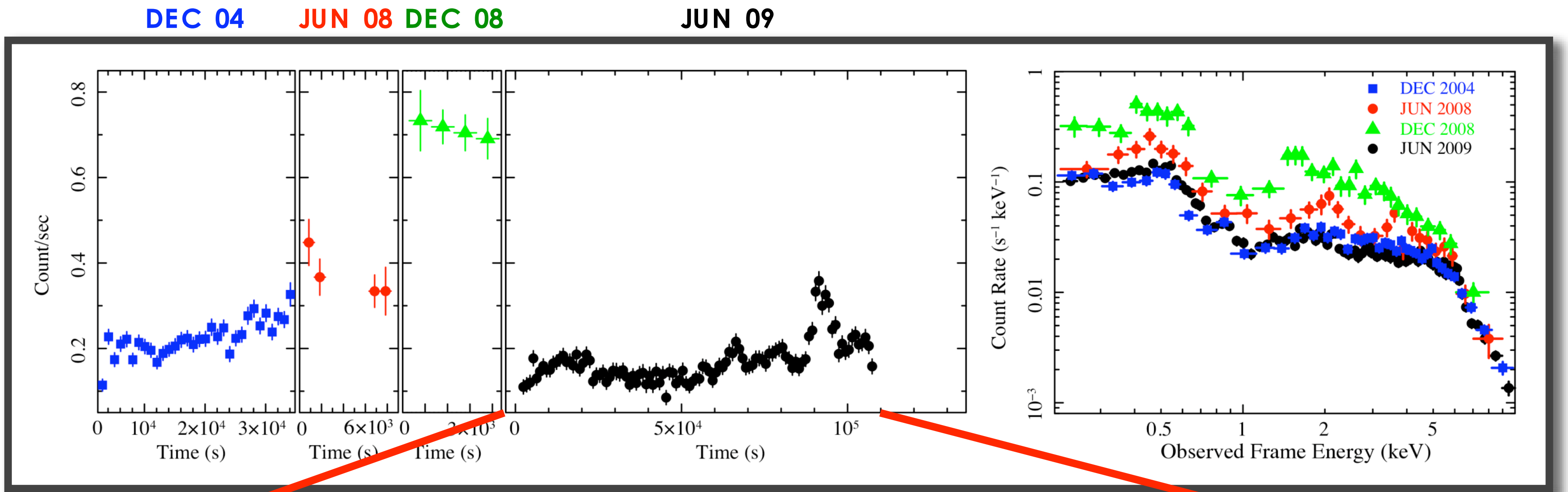
The longest X-ray look ever at a mini-BAL QSO

The new observational campaign on PG 1126-041



Strong variability on time scales of months and hours

The new observational campaign on PG 1126-041



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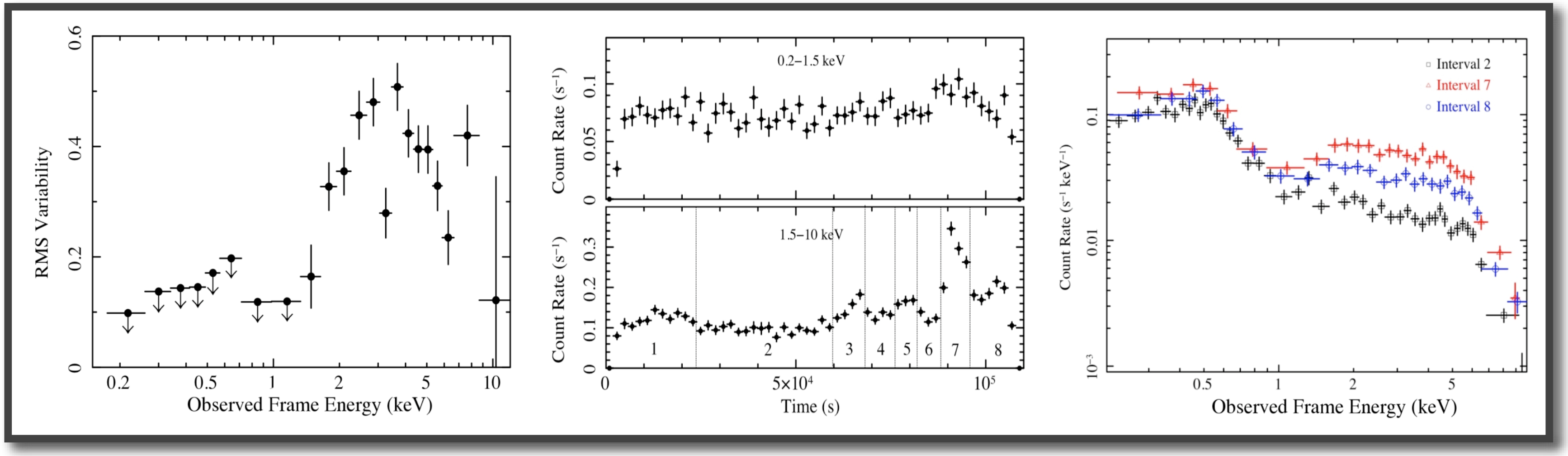
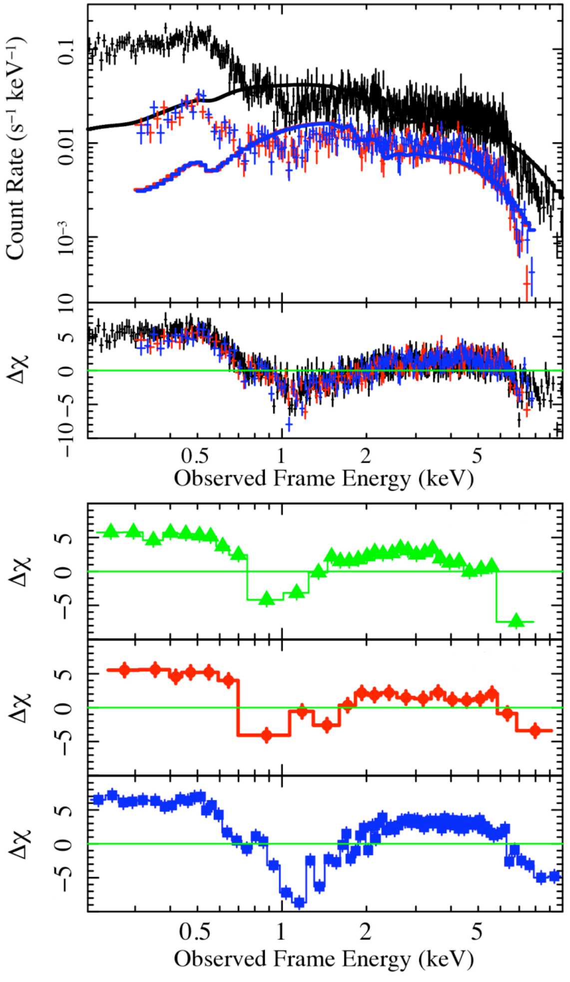


Two distinct spectral components

- **Fit to a simple power law**



χ^2/ν=8801/1591

$\Gamma \sim 0.6$

The new observational campaign on PG 1126-041

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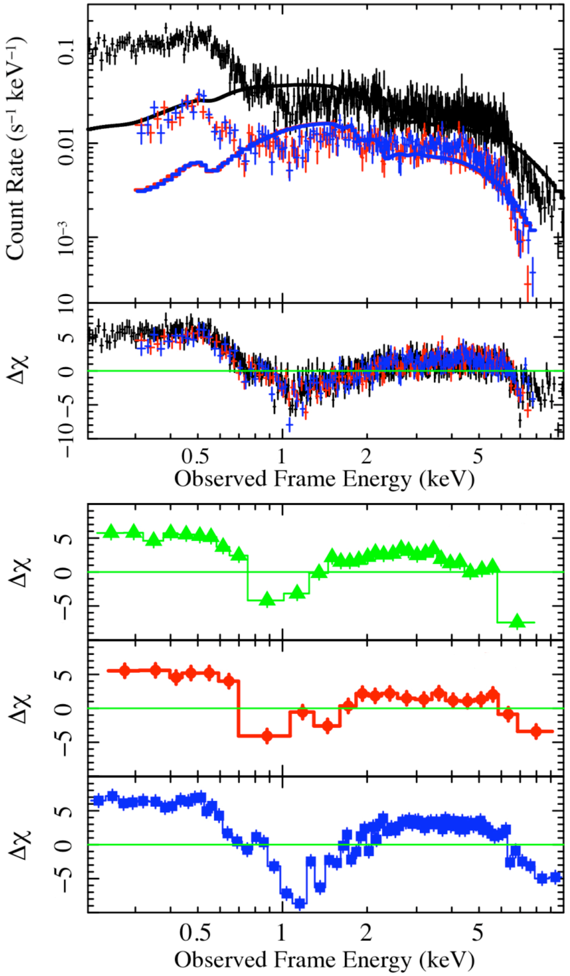

χ^2/ν=8801/1591

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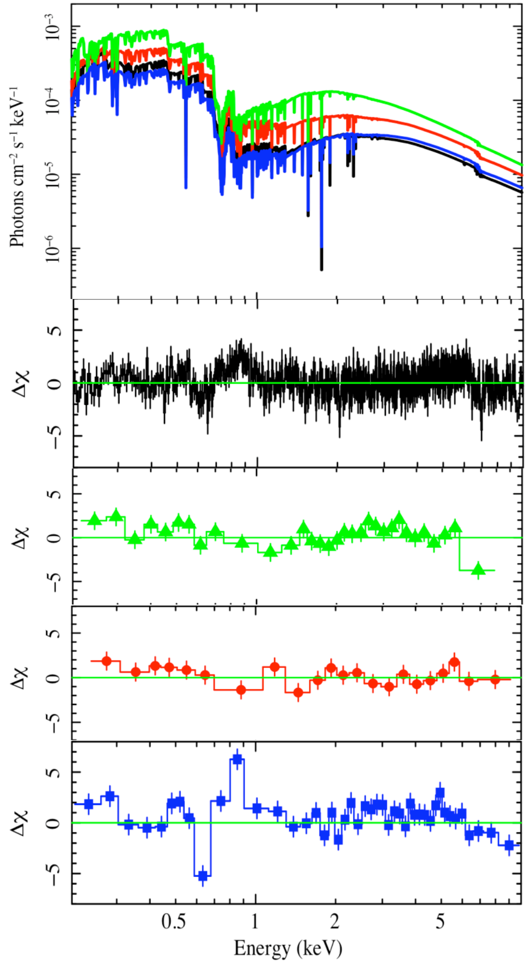
- **Adding a warm absorber**



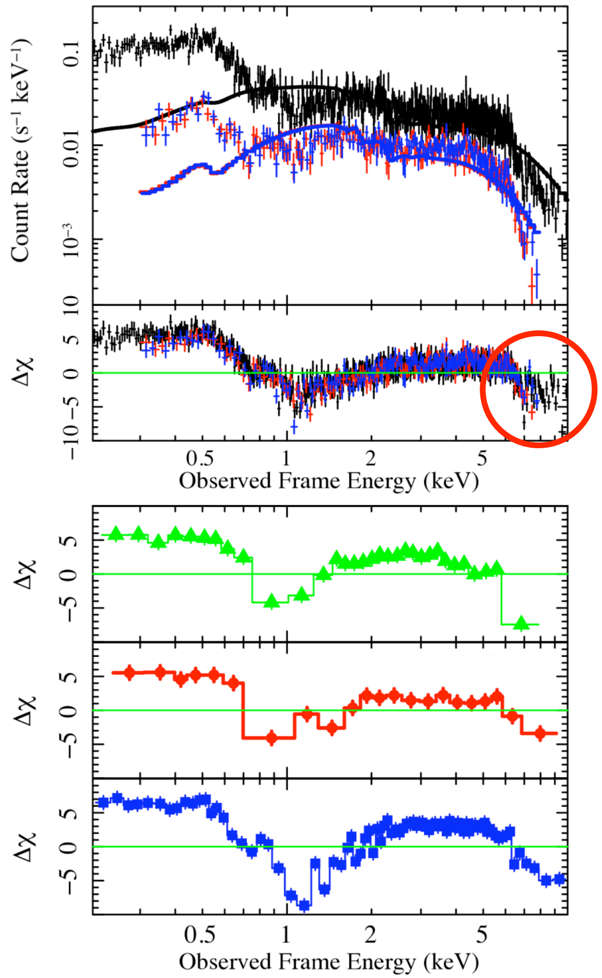
$\Delta\chi^2/\Delta\nu$=6567/8

$\Gamma \sim 2$, $\log\xi \sim 1.5$ erg cm s^{-1},

$\log N_W \sim 22.5\text{-}23.1$ cm^{-2}

The new observational campaign on PG 1126-041

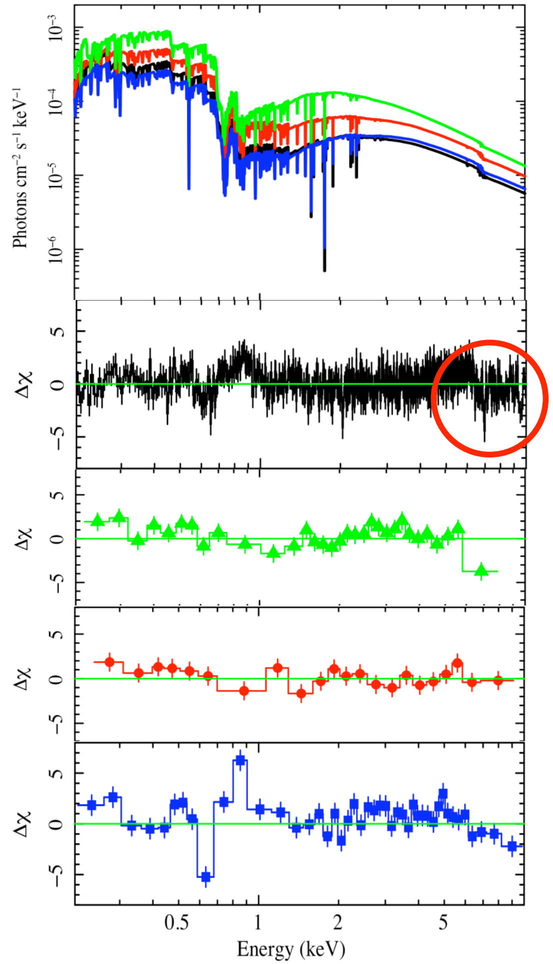
- **Fit to a simple power law**



χ^2/ν=8801/1591

Γ ~ 0.6

- **Adding a moderately ionized absorber**



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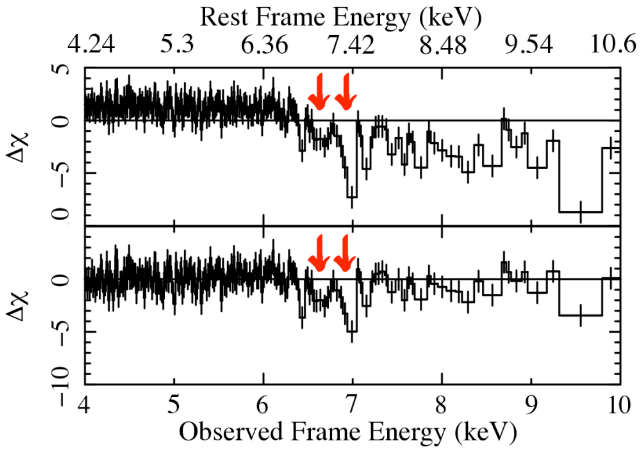
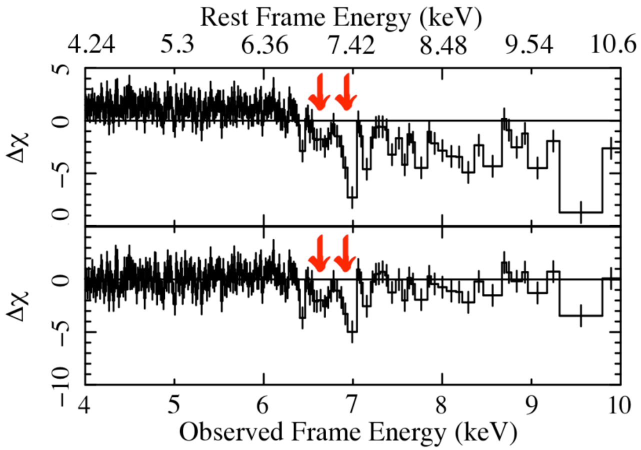
Γ ~ 2, logξ ~1.5 erg cm s^{-1},

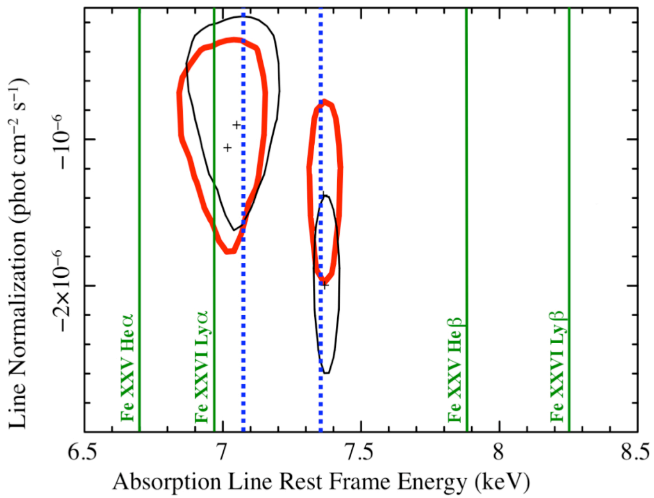
logN_W~22.5-23.1 cm^{-2}

A highly ionized absorber



A highly ionized outflowing absorber

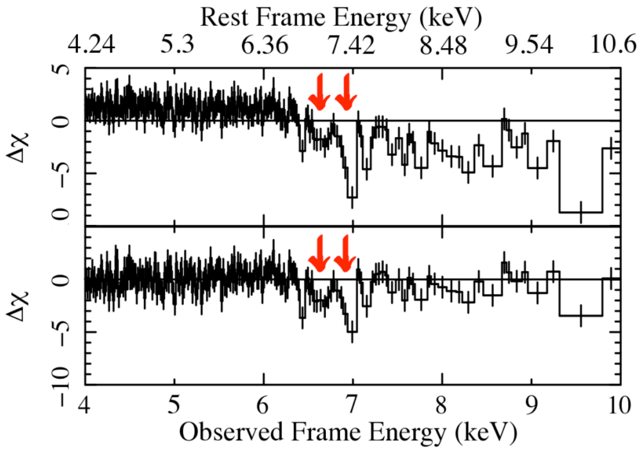


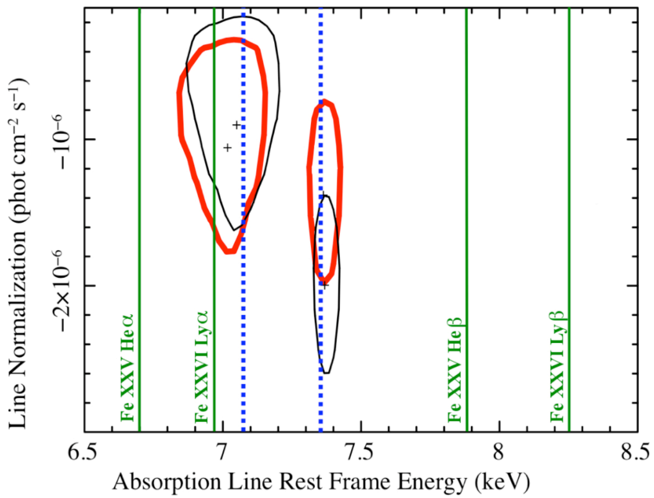


$\Delta\chi^2/\Delta\nu=60/4$

for the 2009 Long Look

A highly ionized outflowing absorber





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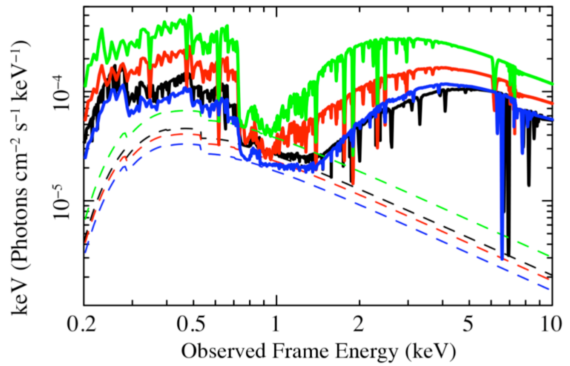
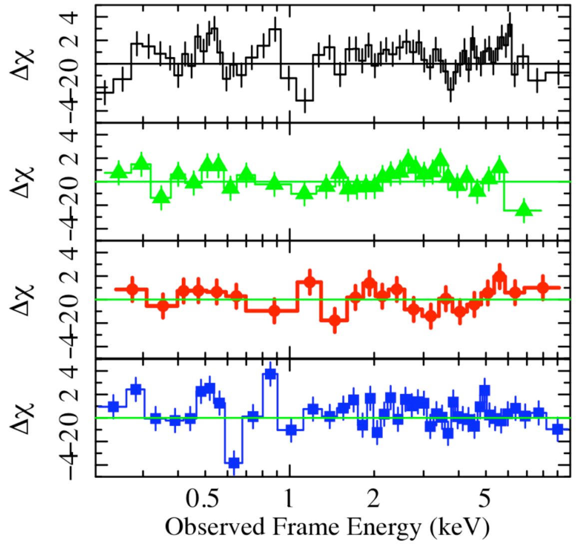


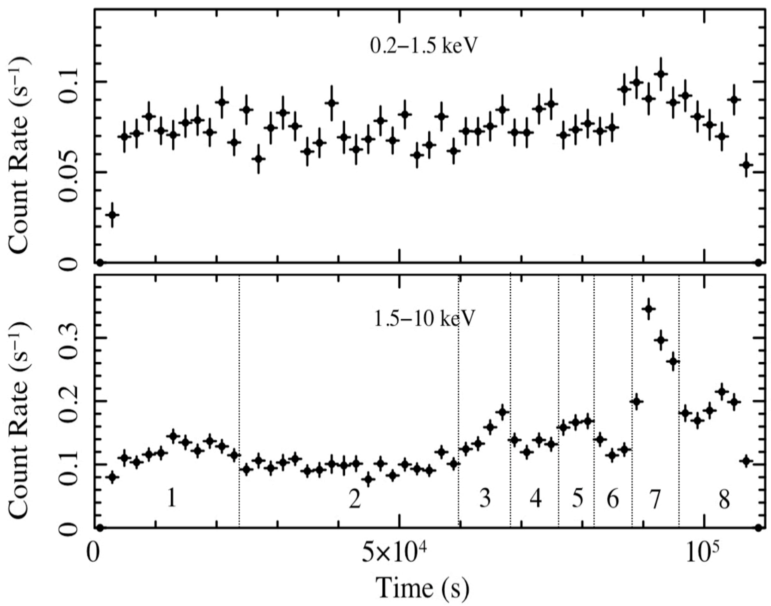


$\Delta\chi^2/\Delta\nu$=122/9

$\log\xi$~3.5 erg cm s^{-1}, $\log N_W$~23.8 cm $^{-2}$

v_{out}~16,500 km s^{-1}

- ***temporally resolved spectral analysis of the 2009 Long Look observation***



0.2-1.5 keV and 1.5-10 keV
light curves binned to 2 ks

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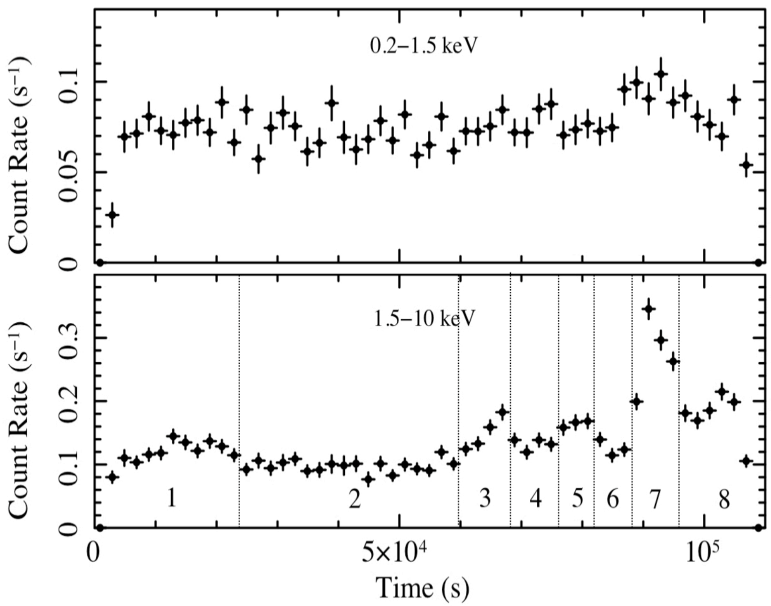

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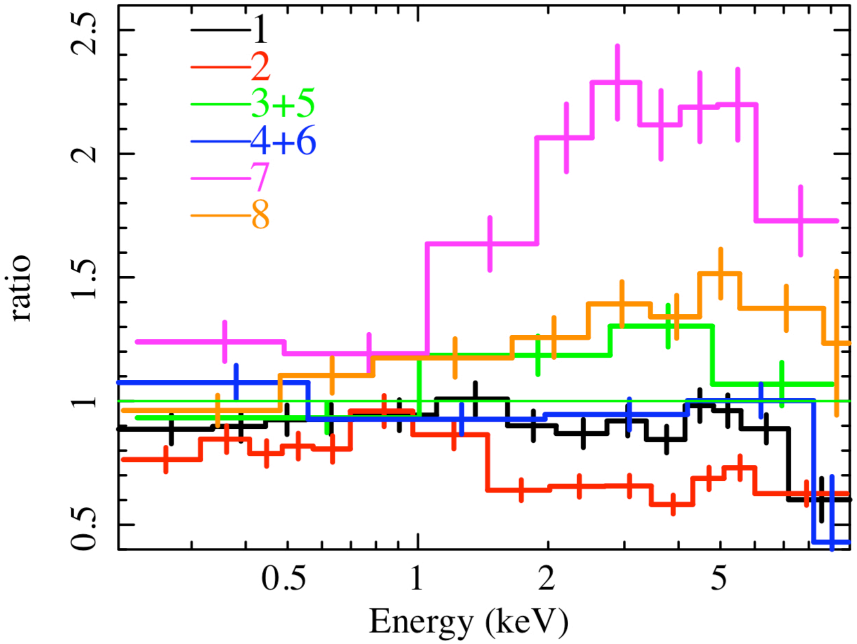

Ratio of each temporal slice to the best fit model of the average 2009 Long Look data: $\chi^2/\nu \sim 2.3$

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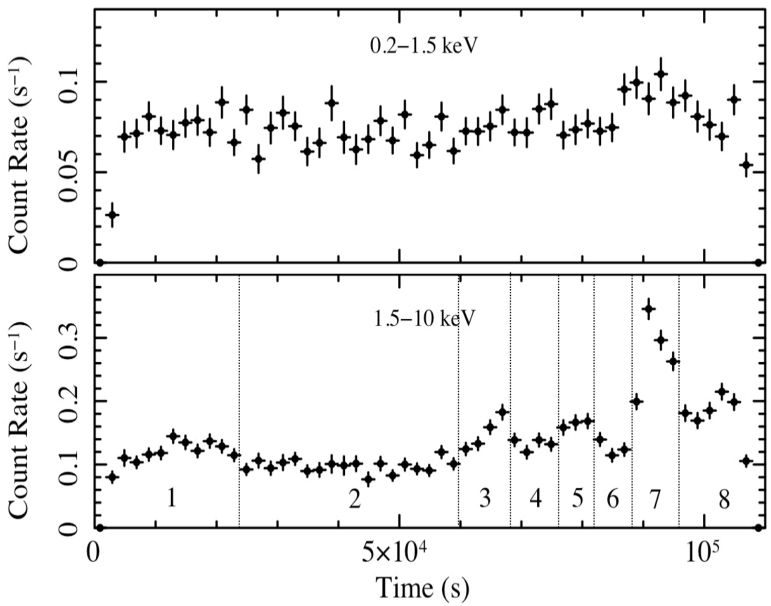

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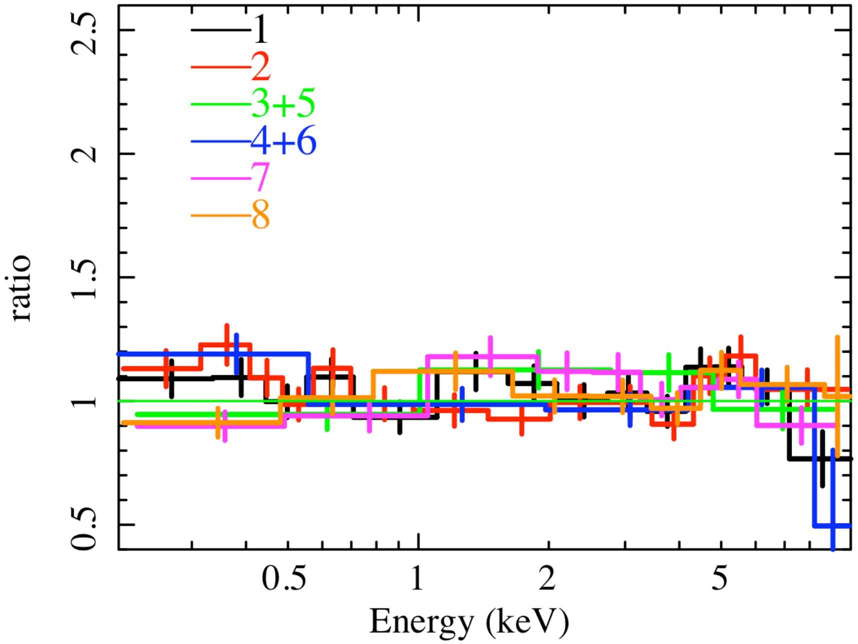

Allowing the continuum amplitude to vary: $\chi^2/\nu \sim 1.0$

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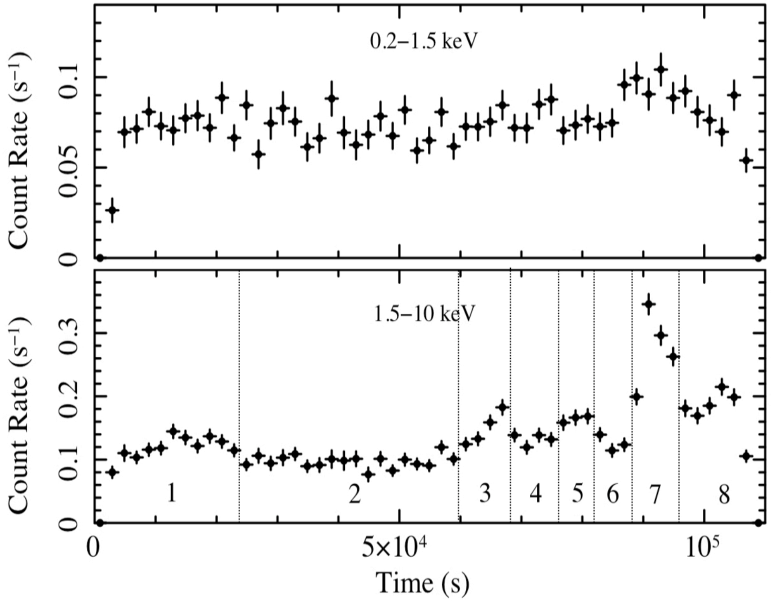

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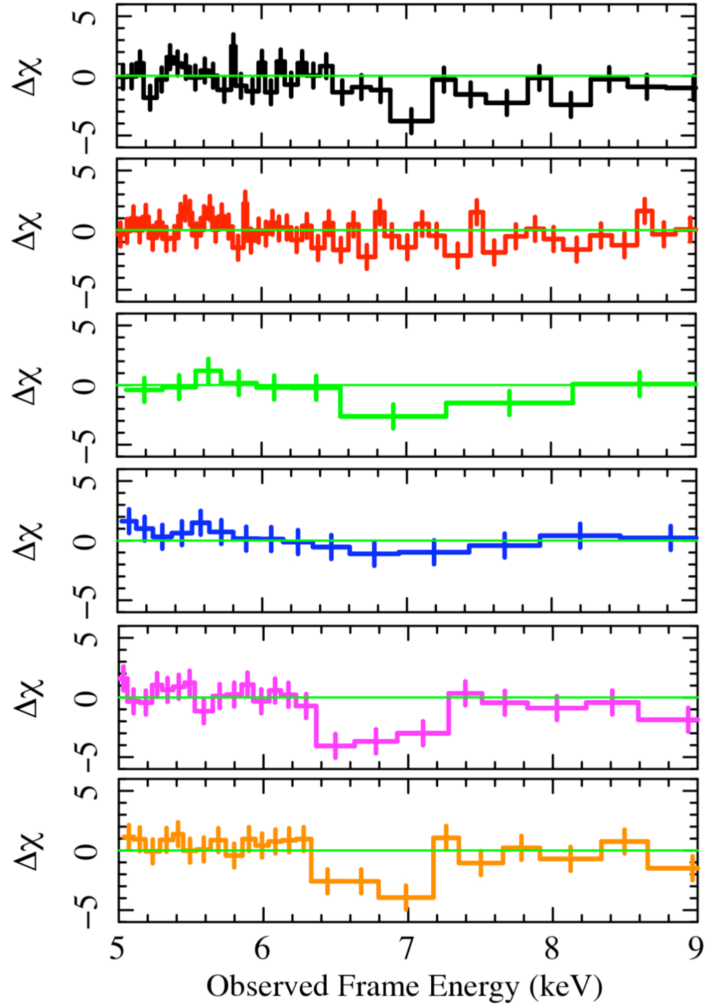

Removing the highly ionized absorber from the model

The new observational campaign on PG 1126-041

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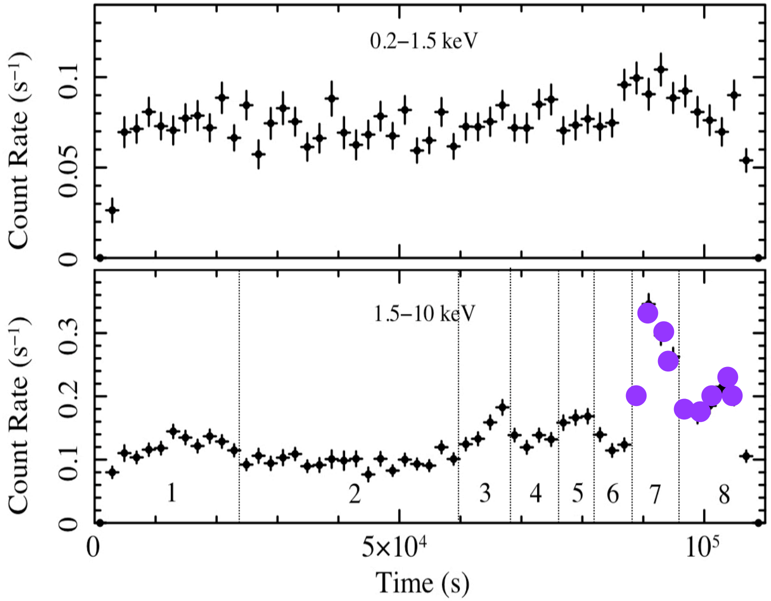

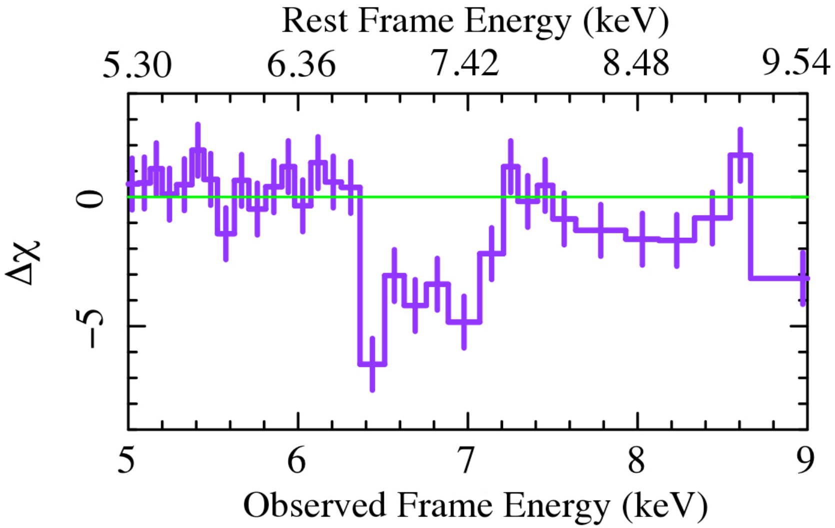

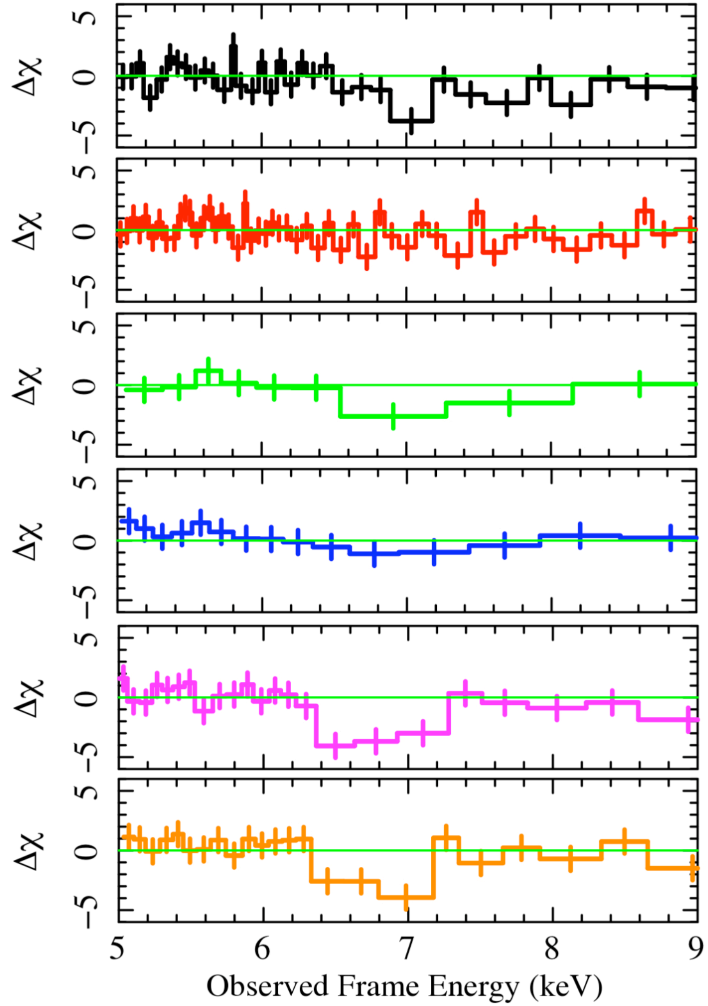

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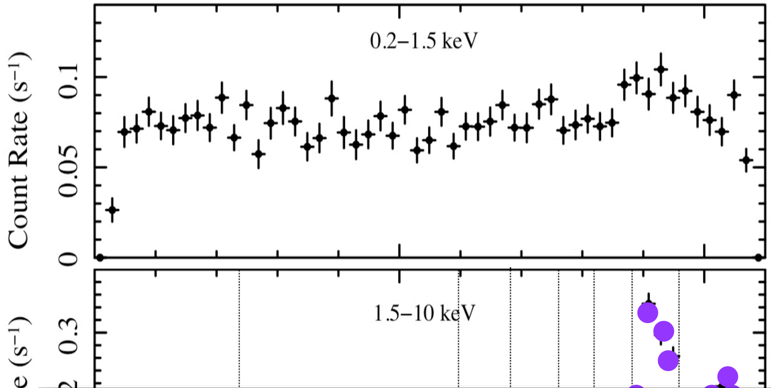
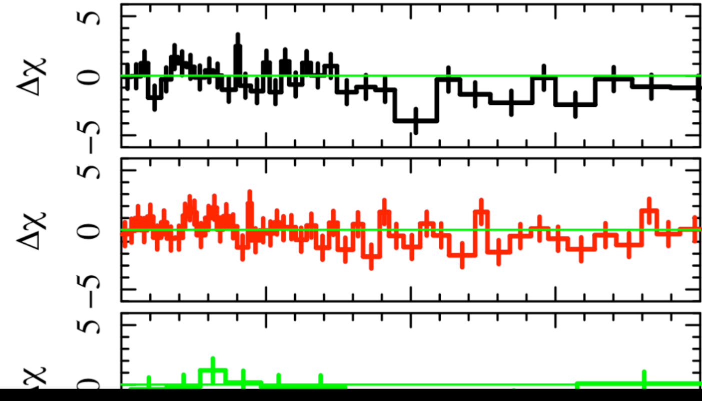
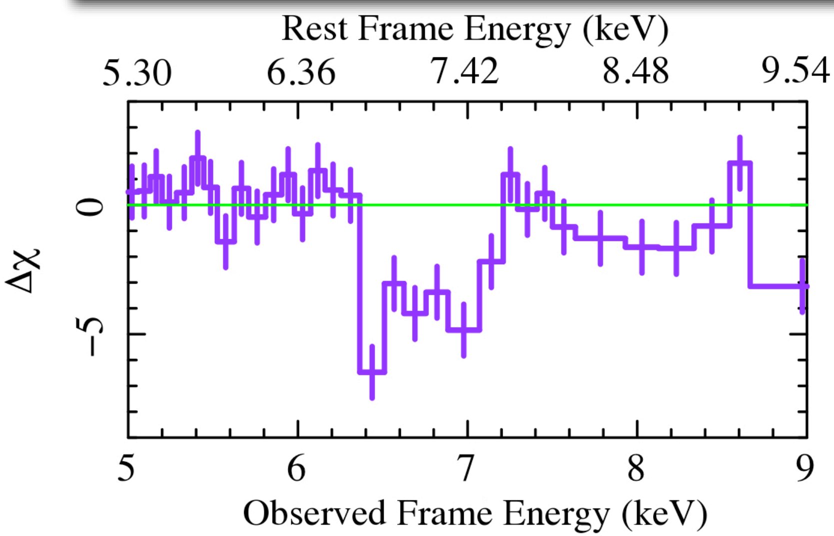
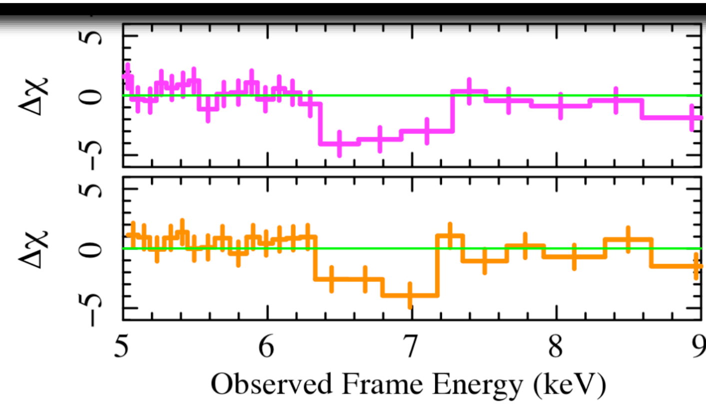




START TO PROBE THE DYNAMICS OF THE INNER ACCRETION/EJECTION FLOW!





Removing the highly ionized absorber from the model

1 **Why?**

A feedback mechanism between the SMBH and its environments

Understanding the AGN structure and the physics of accretion/ejection

2 **What?**

X-ray observations of AGN with powerful winds: N_H, ξ, L_{ion}, Γ, α_{ox}, ...

Constraints on the wind kinematics, v_{out}

Insights on the wind dynamics, Δv_{out}

3 **How?**

Archive: nearby bright sources and distant large samples

A new observational campaign

Theoretical analyses

4 **And So What?**

What's up so far?

What's next?

What's up so far?

- The "X-ray Weak only" paradigm for BAL QSOs is now obsolete.

- The X-ray weakness increases with increasing the width of UV absorption lines, i.e. going from NAL, to mini-BAL, to BAL QSOs.

- Massive, VARIABLE, ionized absorbers have been detected in the highest S/N X-ray spectra, and are likely present in most of the sources.

- There are no evidences for an intrinsic continuum different from type 1 AGN.

- Strong spectral VARIABILITY is found over different time scales, finally opening the way to dynamical studies.

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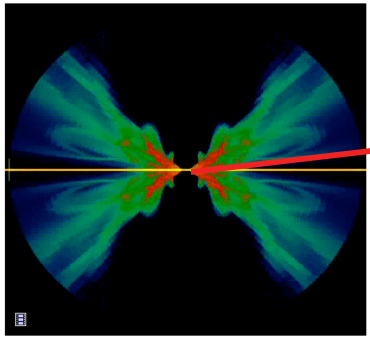

Classical BAL QSOs

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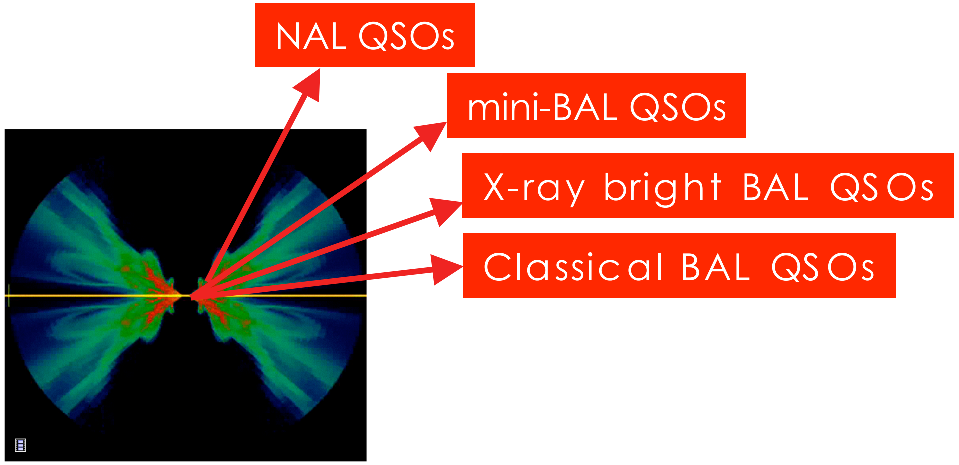

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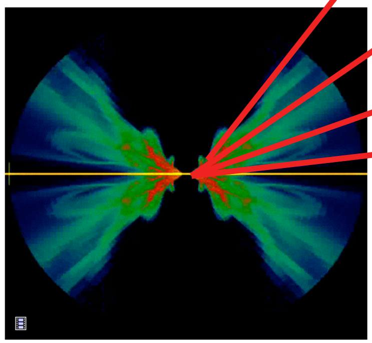


NAL QSOs — *is there highly ionized gas?*

mini-BAL QSOs — *it's time to (get ready to) start probing the dynamics!*

X-ray bright BAL QSOs — *connection with the X-ray weak BAL QSOs?*

Classical BAL QSOs — *will we ever see a high quality X-ray spectrum?*

Evolution must also be important.

What's up so far?

- **What about the feedback?**

kinetic efficiency of the wind

$$\varepsilon_w \propto \frac{\dot{M}_{out} v_{out}^2}{L_{acc}}$$

mass outflow rate

$$\dot{M}_{out} \propto A(r)\rho(r)v_{out}(r)$$

Assuming spherical symmetry, isotropy, constant velocity:

$$\dot{M}_{out} = 4\pi m_H n r^2 v_{out} C_f F_V$$

Assuming photoionization equilibrium, and the absorber as a thin shell:

$$\dot{M}_{out} = 4\pi m_H \frac{L_{ion}}{\xi} v_{out} C_f F_V$$

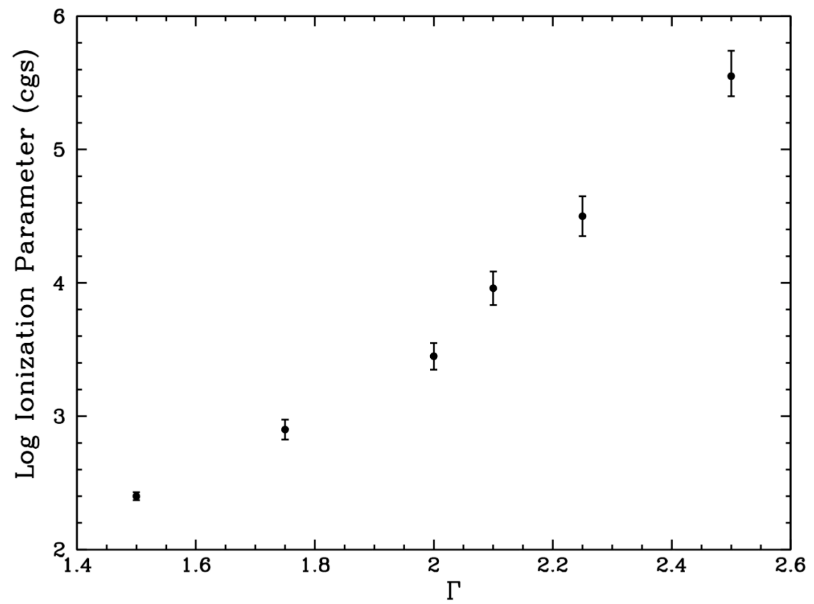
↓

$$\dot{M}_{out} \approx \dot{M}_{acc},\ \varepsilon_w \approx \text{ up to a few \%}$$

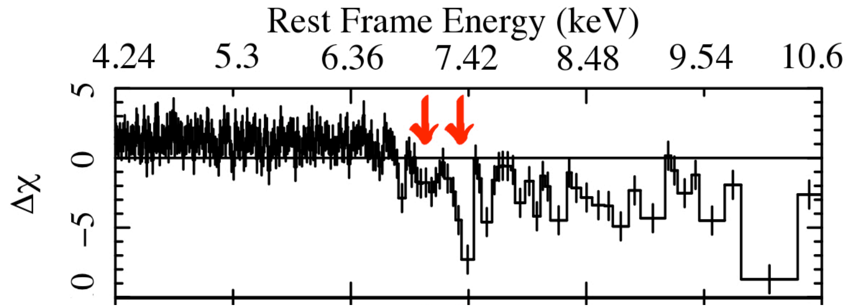
For the highly ionized, high velocity phases.

BUT

All the assumptions are highly uncertain!



Large systematic uncertainty ***also*** *on ξ*



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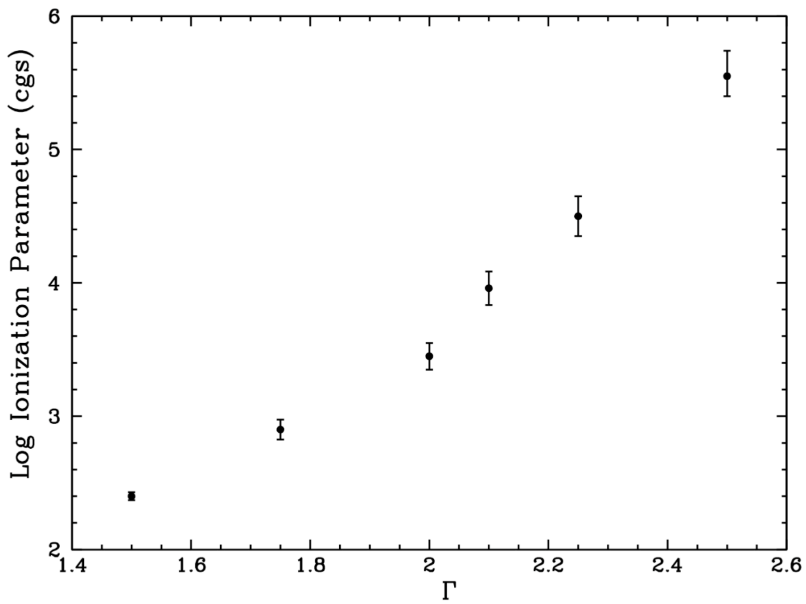
BUT

All the assumptions are highly uncertain!



Large systematic uncertainty ***also*** *on ξ*

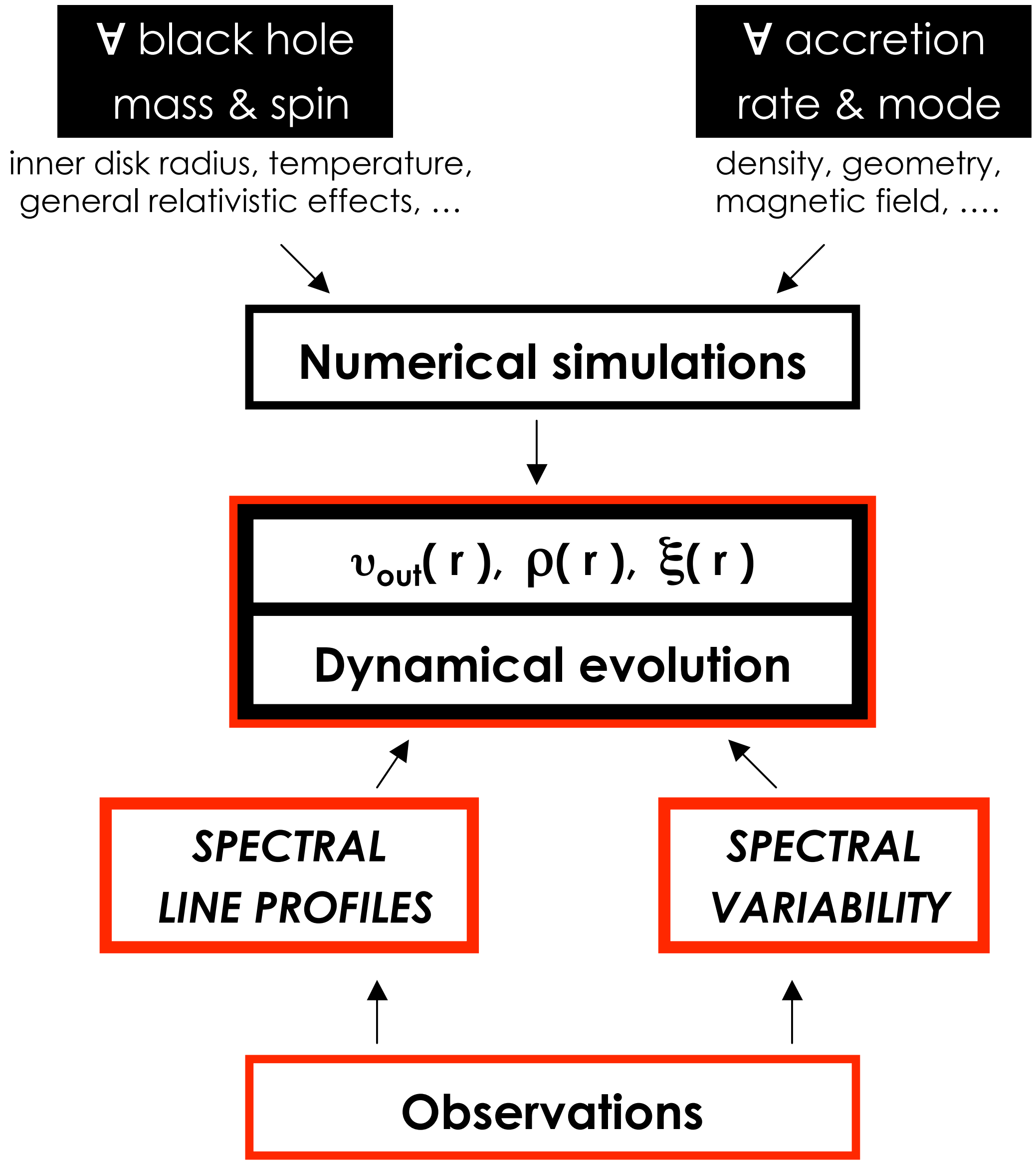
Be careful with mass outflow rate "rough estimates"

unveiling the physics of accretion onto SMBH

⇕

how much energy is carried by the wind?

What's next?



Spanning the widest possible range of QSO properties across the cosmic time

Thanks for your attention!

What's next?

NAL/mini-BAL/BAL QSO connection?

Wind evolution with L_{acc}/L_{Edd}, M_{BH} over cosmic time?

Geometry of the wind?

Wind global incidence/duty cycle?

Inner structure of AGN?

Cosmic Feedback?

Low z: detailed astrophysics!

We want to go to z~2!

BETTER SPECTRAL RESOLUTION: EXTREMELY IMPORTANT

LARGER EFFECTIVE AREA: MANDATORY

NOW

Time resolved spectral analysis, possibly UV/X-ray simultaneous

Get ready with theoretical predictions/expectations

IN THE NEAR FUTURE

Start tasting high spectral resolution in a few sources with ASTRO-H

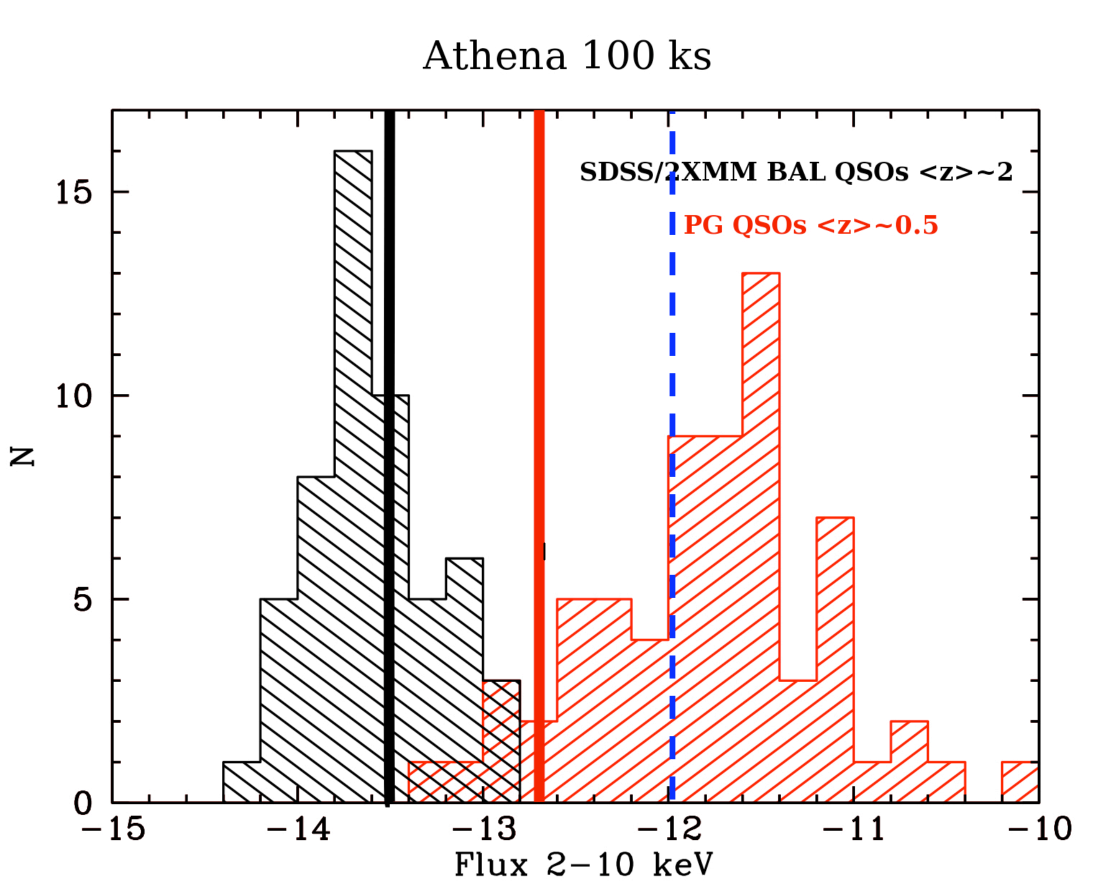
NOT TOO FAR AWAY

The decisive step: a next generation X-ray observatory: ATHENA

What's next?

POPULATION STUDIES

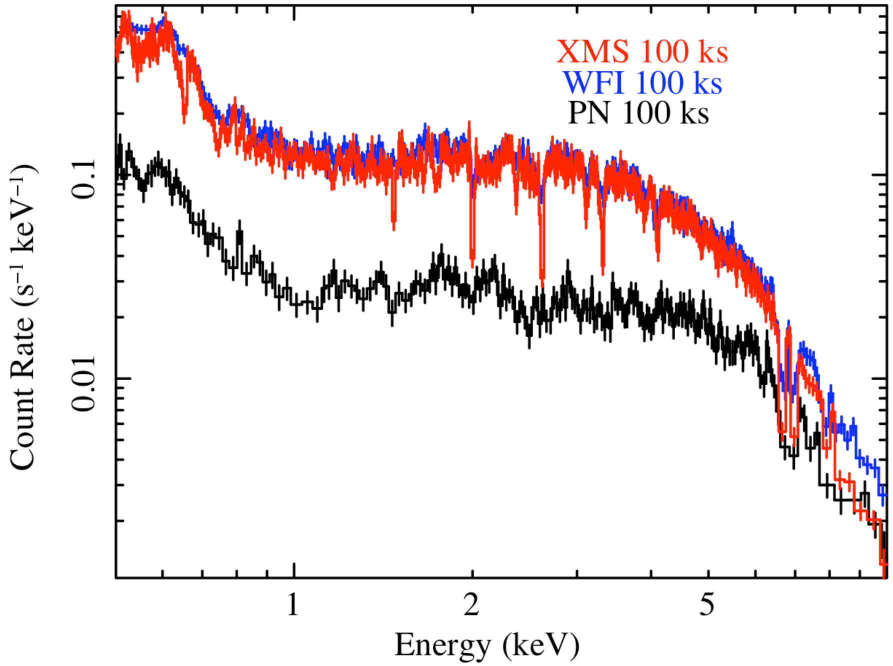
Minimum 2-10 keV flux to constrain (N_W, ξ) within (20%, 10%) in a 100 ks observation

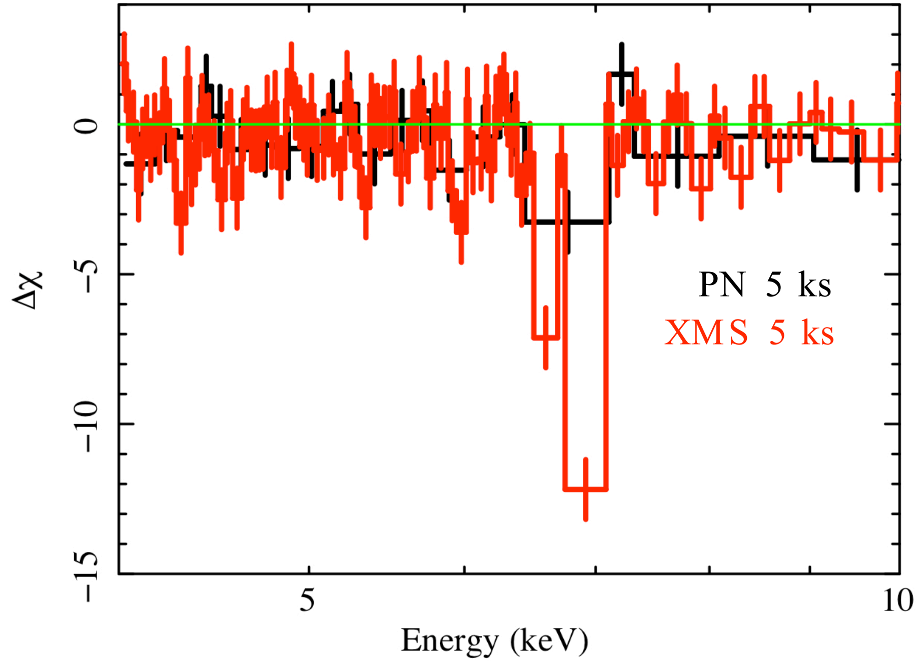


QUANTIFY AGN FEEDBACK UP TO z~2

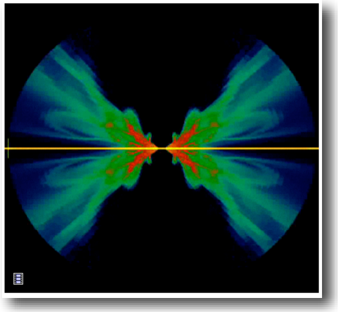
INDIVIDUAL DETAILED STUDIES

The ATHENA view of a mini-BAL QSO



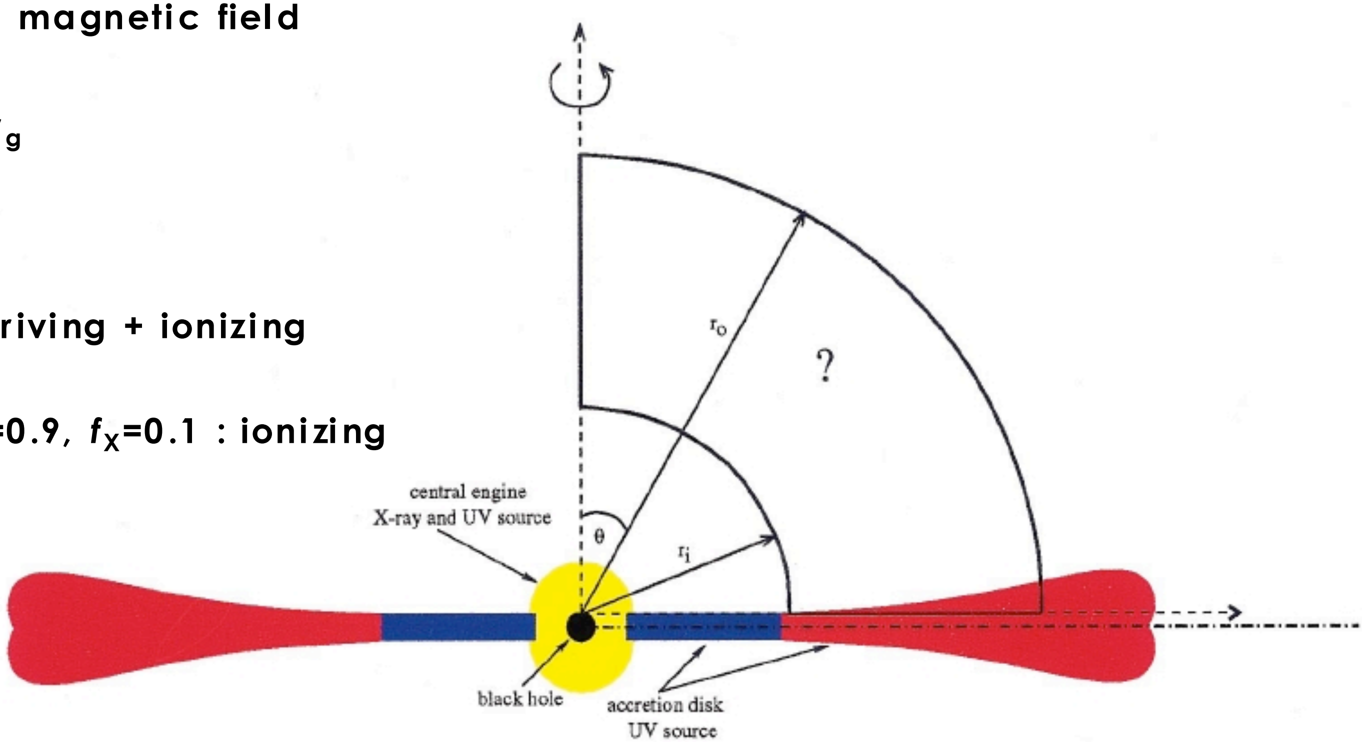


UNVEIL THE DYNAMICS OF THE INNER ACCRETION/EJECTION FLOW

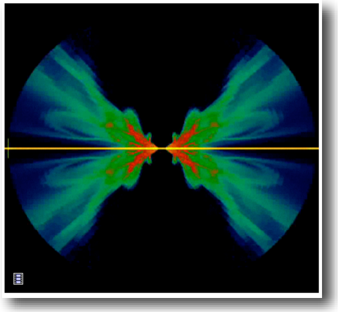


- Synthetic absorption line profiles for continuum point sources and different wind geometries. Example: Proga & Kallman 2004, UV line driven wind
- What happens when breaking down the spherical symmetry assumption?

- **2D, axysimmetric, no magnetic field**
- **10-500 R_0 = 60-3000 r_g**
- **$M_{BH}=10^8 M_{sun}$**
- **$\lambda=0.5$, $L_{disk}=0.5L_{Edd}$: driving + ionizing**
- **$L_{eng}=(f_{UV}+f_X)L_{disk}$, $f_{UV}=0.9$, $f_X=0.1$: ionizing**



Theoretical Analyses



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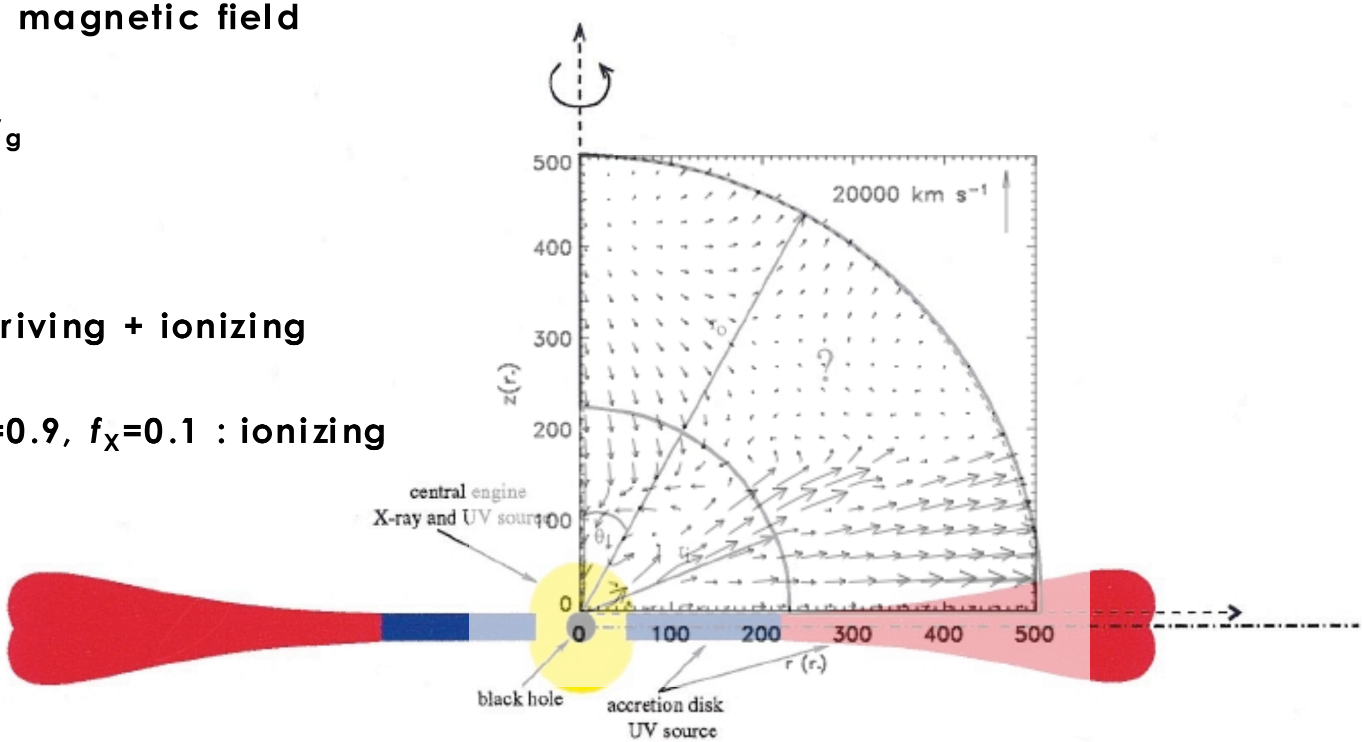
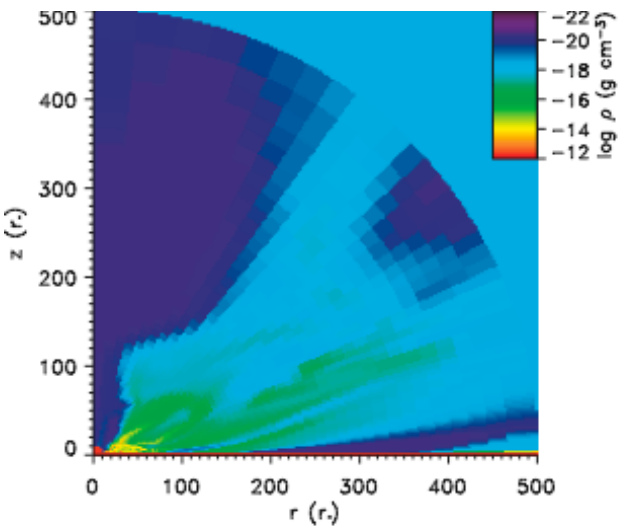
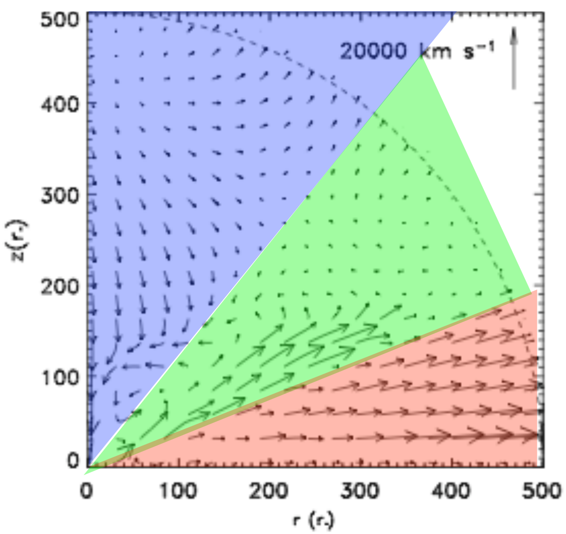


density



poloidal velocity



Hot, low density polar flow

very high ionization state
negligible contribution to M_{out}

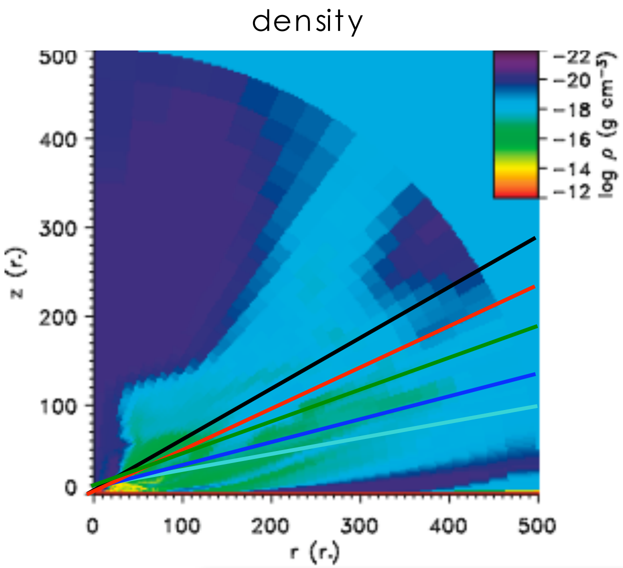
Transitional, struggling zone

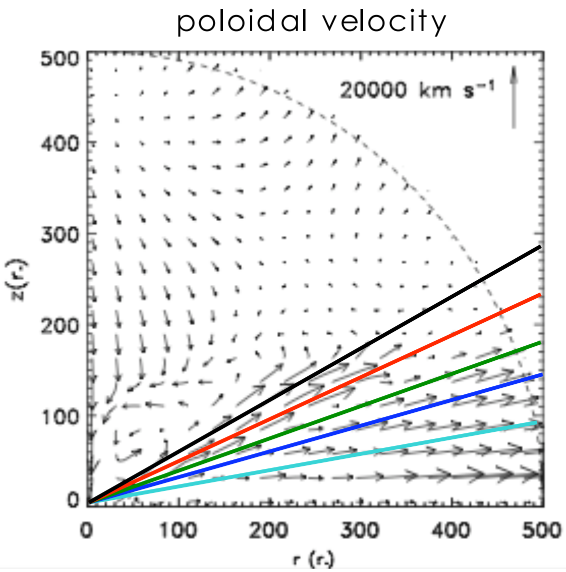
hot, highly variable,
sporadic high-υ ejections

Warm, dense equatorial outflow

inner region: failed wind
outer region: fast stream

Theoretical Analyses





Hot, low density polar flow

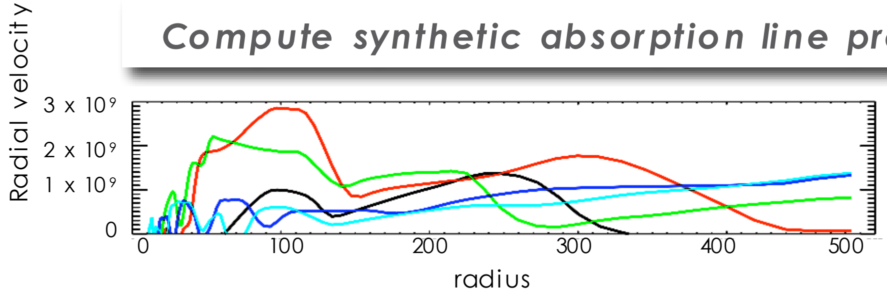
Transitional, struggling zone

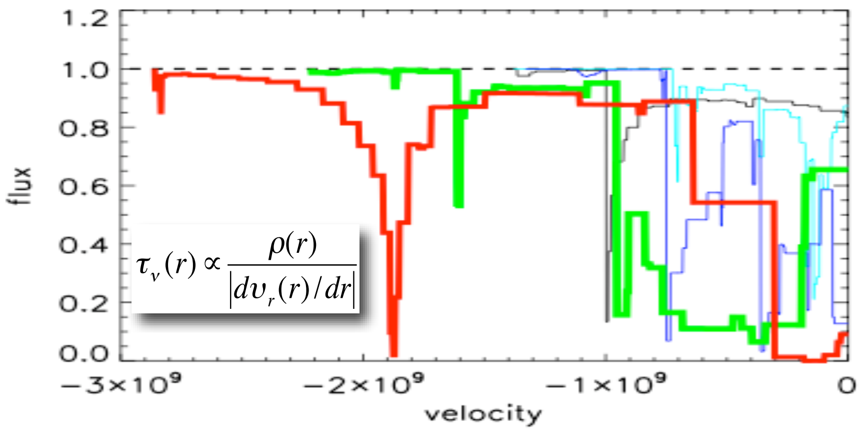
θ = **60**, **65**°

Warm, dense equatorial outflow

θ = **70**, **75**, **80**°

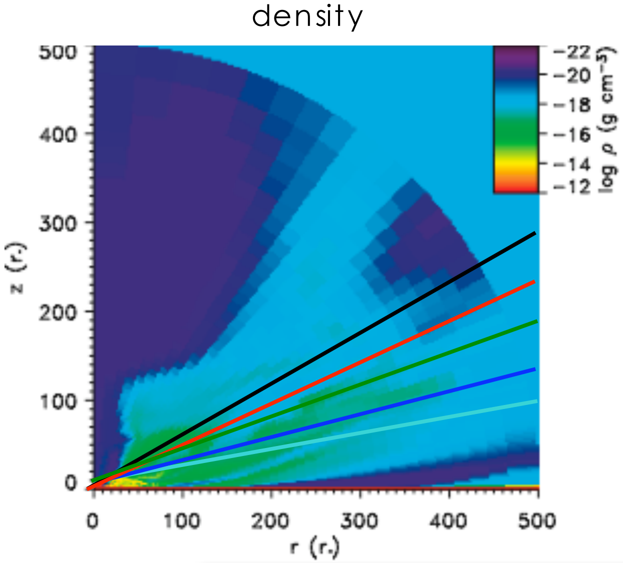
Compute synthetic absorption line profiles for different inclination angles

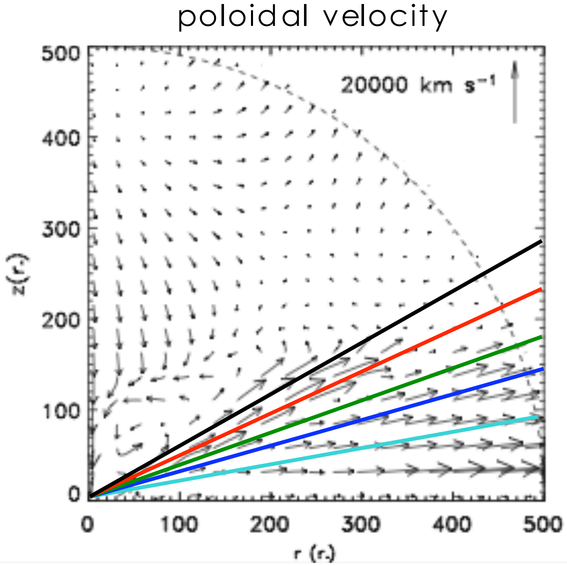


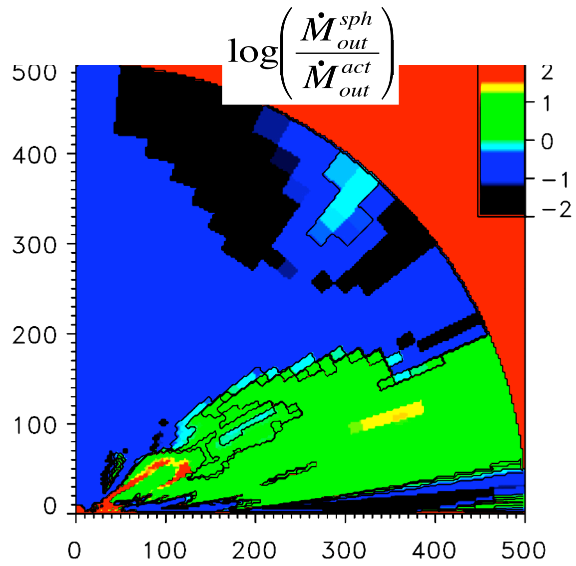


- Mass escapes only from the equatorial region, θ > 65°
- θ = 65° the most blueshifted features: form around r=100 R_0, do not escape the system.
- θ = 70° less blueshifted features: form at large radii, escape the system.

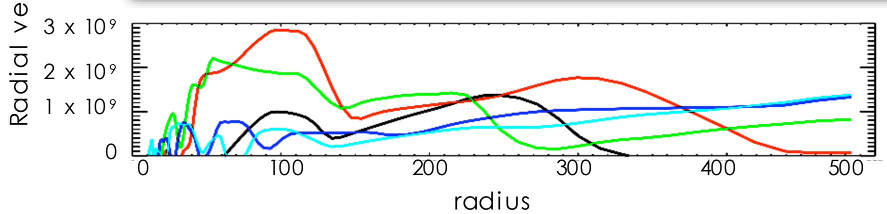
Theoretical Analyses

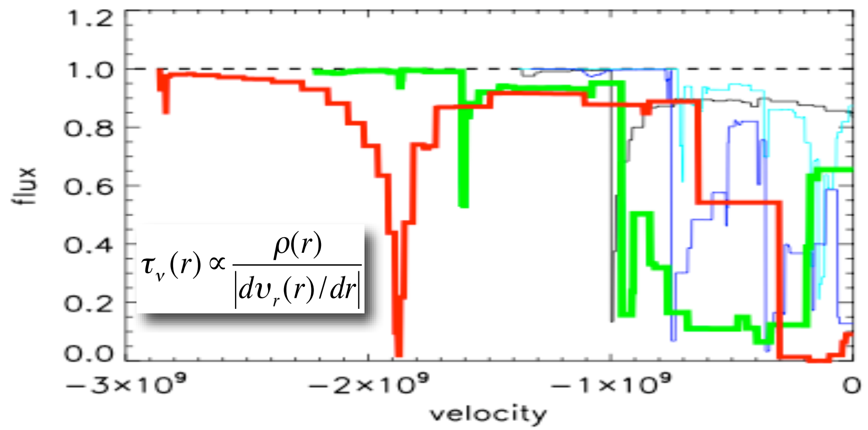






Compute synthetic absorption line profiles for different inclination angles





- Mass escapes only from the equatorial region, θ > 65°
- θ = 65° the most blueshifted features: form around r=100 R_0, do not escape the system.
- θ = 70° less blueshifted features: form at large radii, escape the system.
- ***No one to one correspondence between the observed blueshift and the actual kinetic efficiency of the wind***

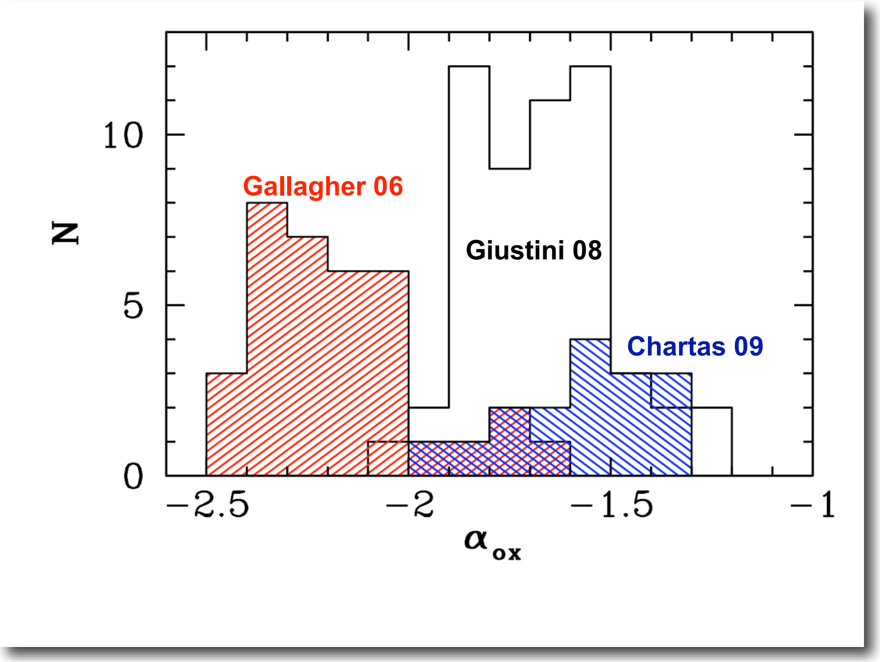
The NAL QSO sample

➲ **Chartas et al. 2009 NewAR 53, 128**

"High velocity outflows in NAL QSOs"

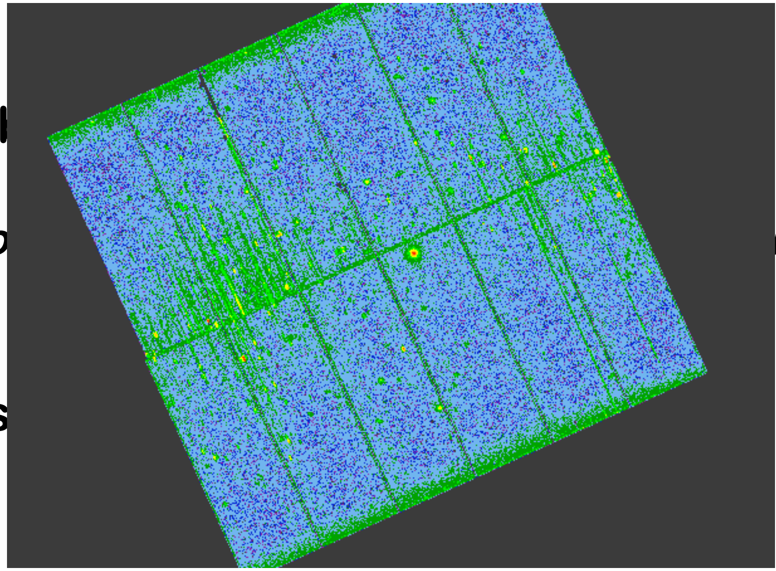
- 16 QSOs with intrinsic high velocity NALs *from Misawa et al. 2007*
- **(XMM + Suzaku) × (Keck + VLT)** : 2 < z < 3

- *All X-ray detected*
- *Typical continuum* $< \Gamma > \sim 1.9$
- *Very low measured neutral absorbing* $< N_H > \sim < N_{H,GAL} >$
- *All X-ray bright*



➲ physical link

Is radiatio ... L the winds?

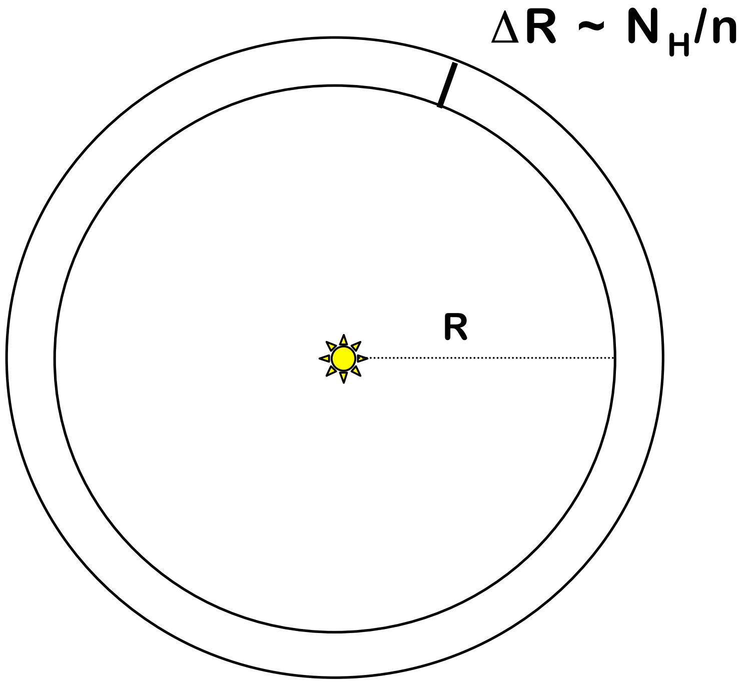


➲ how much mas

Geometry

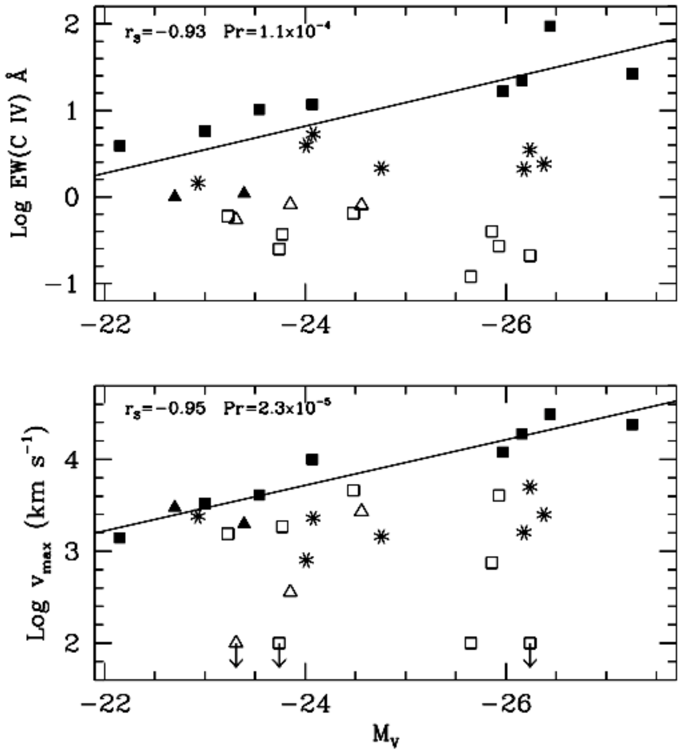
➲ which is the behavior as a population, i.e. their role in the QSO life?

Bigger samples, better statistics: new X-ray telescopes?

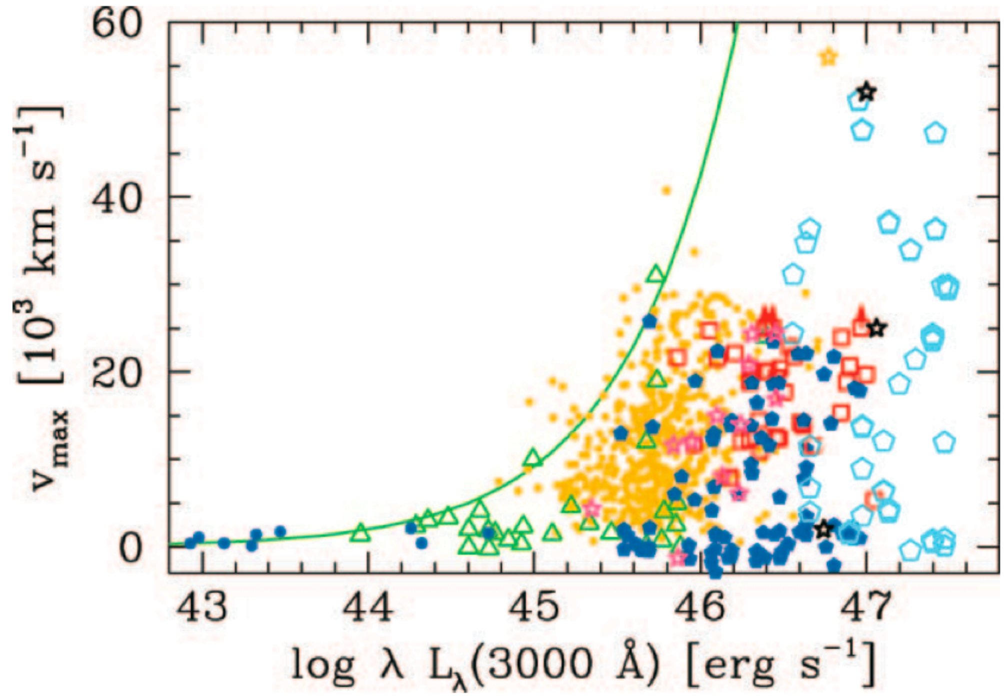

$\Delta R \sim N_H/n$
R

AGN winds: observational evidences

Radiation pressure probably plays a role



Laor & Brandt 2002



Ganguly & Brotherton 2008

	warm absorbers	UV NALs	UV mini-BALs	UV BALs	X-ray UFOs	X-ray BALs	
$\log\xi$	0 … 4	-2 … 0	-2 … 0	-2 … 0	3 … 5	3 … 5	erg cm s^{-1}
$\log N_H$	20 … 22	20 … 22	21 … 23	21 … 23	23 … 24	23 … 24	cm^{-2}
$\log \upsilon_{out}$	2 … 3	2 … 4	3 … 4	3 … 4	4 … 5	4 … 5	km s^{-1}
%	50 %	30? %	30? %	20 %	40 %	? %	

pc-scale and beyond: torus/NLR

pc-scale and within: accretion disk

Thermal driving

Radiation/Magnetic driving

X-ray observations of AGN winds

80s

90s

2000

2008

2011

BAL QSOs
- discovered
- X-ray Weak
- first RL BAL QSO
- X-ray absorbed
- complex X-ray absorption
- typical underlying SED

Warm Absorber
- discovered
- 50% of type I AGN
- outflowing

mini-BAL QSOs
- discovered
- complex X-ray absorption

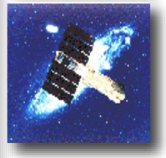
Low-υ UV NALs
- discovered

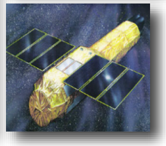
High-υ UV NALs
- discovered
- first X-ray study

X-ray UFOs
- discovered

X-ray BALs
- discovered





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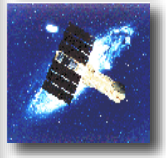
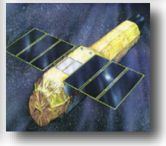
X-ray UFOs
- discovered

X-ray BALs
- discovered

? ? ?





X-ray observations of AGN with powerful winds: N_H, ξ, L_{ion}, α_{ox} ...

Constraints on the wind kinematics, insights on the wind dynamics

And so what?

80s | 90s | 2000 | 2008 | 2011

BAL QSOs
- discovered
- X-ray Weak
- first RL BAL QSO
- X-ray absorbed
- complex X-ray absorption
- typical underlying SED

Warm Absorber
- discovered
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mini-BAL QSOs
- discovered
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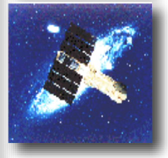
Low-υ UV NALs
- discovered

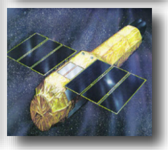
High-υ UV NALs
- discovered
- first X-ray study

X-ray UFOs
- discovered

X-ray BALs
- discovered



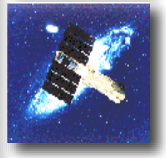


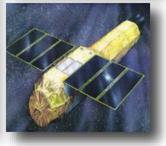



And so what?

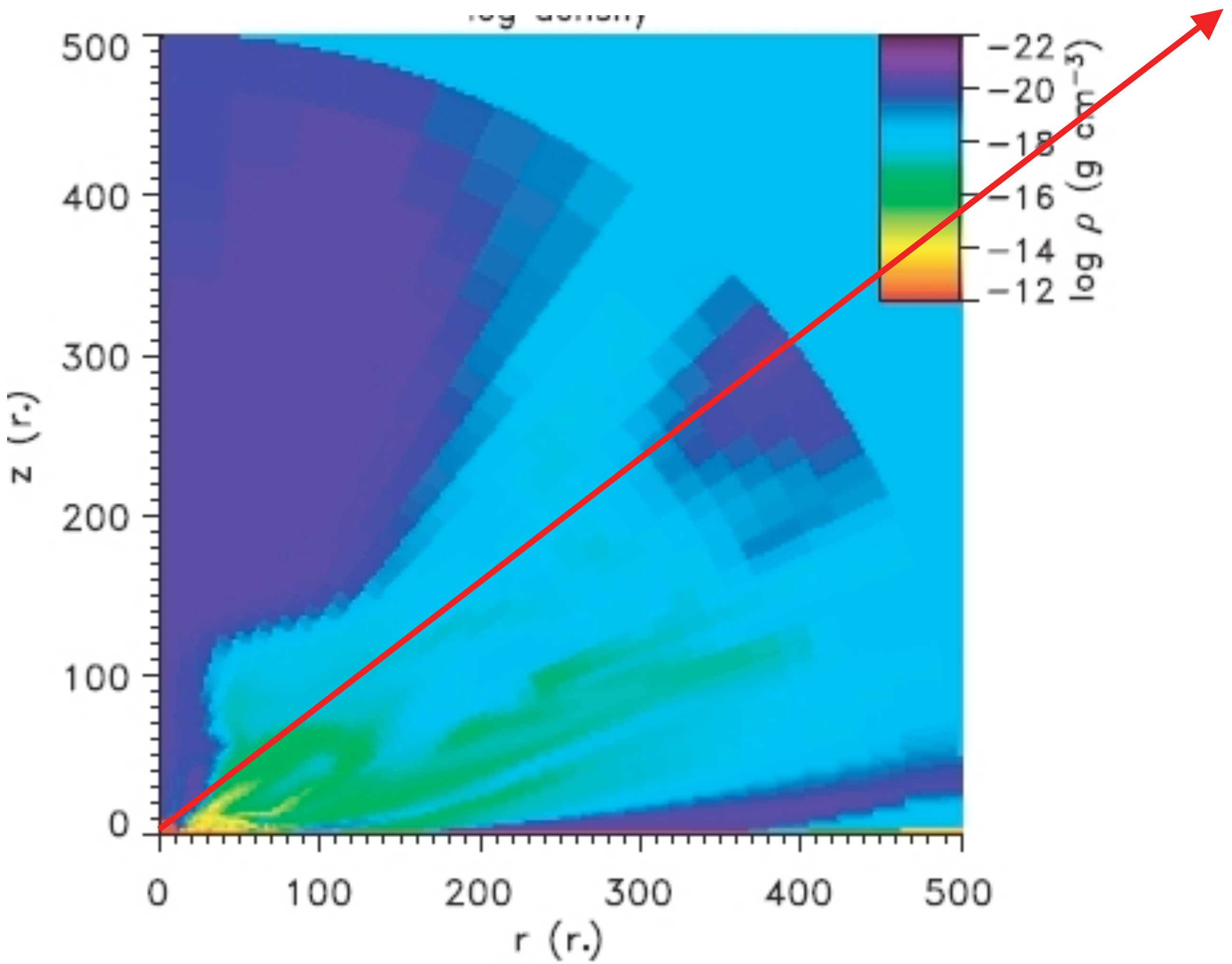
	BAL QSOs	Warm Absorber	mini-BAL QSOs	Low-υ UV NALs / High-υ UV NALs	X-ray UFOs	X-ray BALs
80s	• discovered	• discovered		Low-υ UV NALs • discovered		
90s	• X-ray Weak		• discovered			
	• first RL BAL QSO	• 50% of type I AGN		High-υ UV NALs • discovered		
	• X-ray absorbed		• complex X-ray absorption			
2000	• complex X-ray absorption	• outflowing			• discovered	• discovered
	• typical underlying SED			• first X-ray study		
2008	• X-ray bright subpopulation	• In RL AGN as well	• X-ray bright and variable	• X-ray bright	• Statistically established	• Statistically established
	• Emerging outflows				• In RL AGN as well	• Monitoring
2011	• Variable fraction with z		• First X-ray deep analysis: flow dynamics		• discovered in a mini-BAL	





Scenario: radiatively driven accretion disk wind



Density gradient along the line of sight

The new observational campaign on PG 1126-041