SS3C : BLACK HOLES UNDER THE MAGNIFYING GLASS OF XRISM AND ATHENA

A deep look at Compton-thick AGN with XRISM and Athena

by

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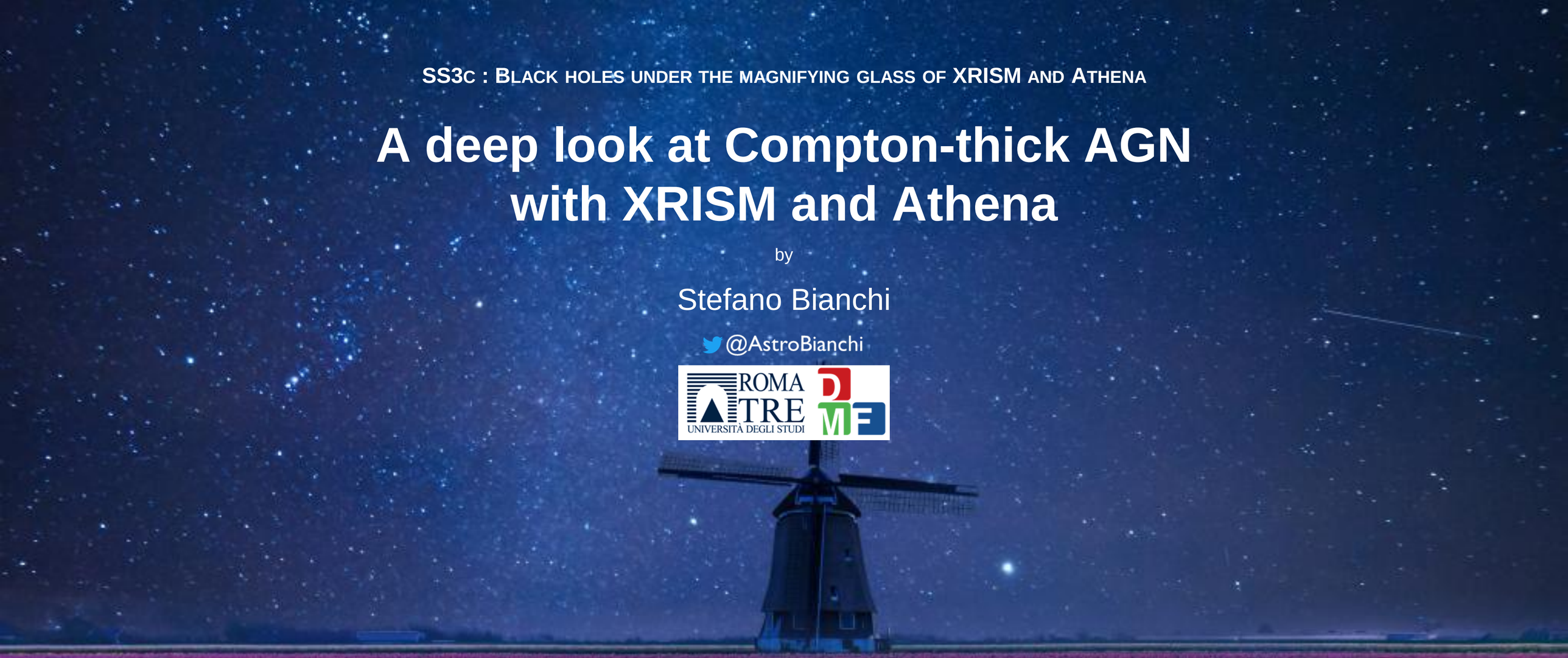
DMF



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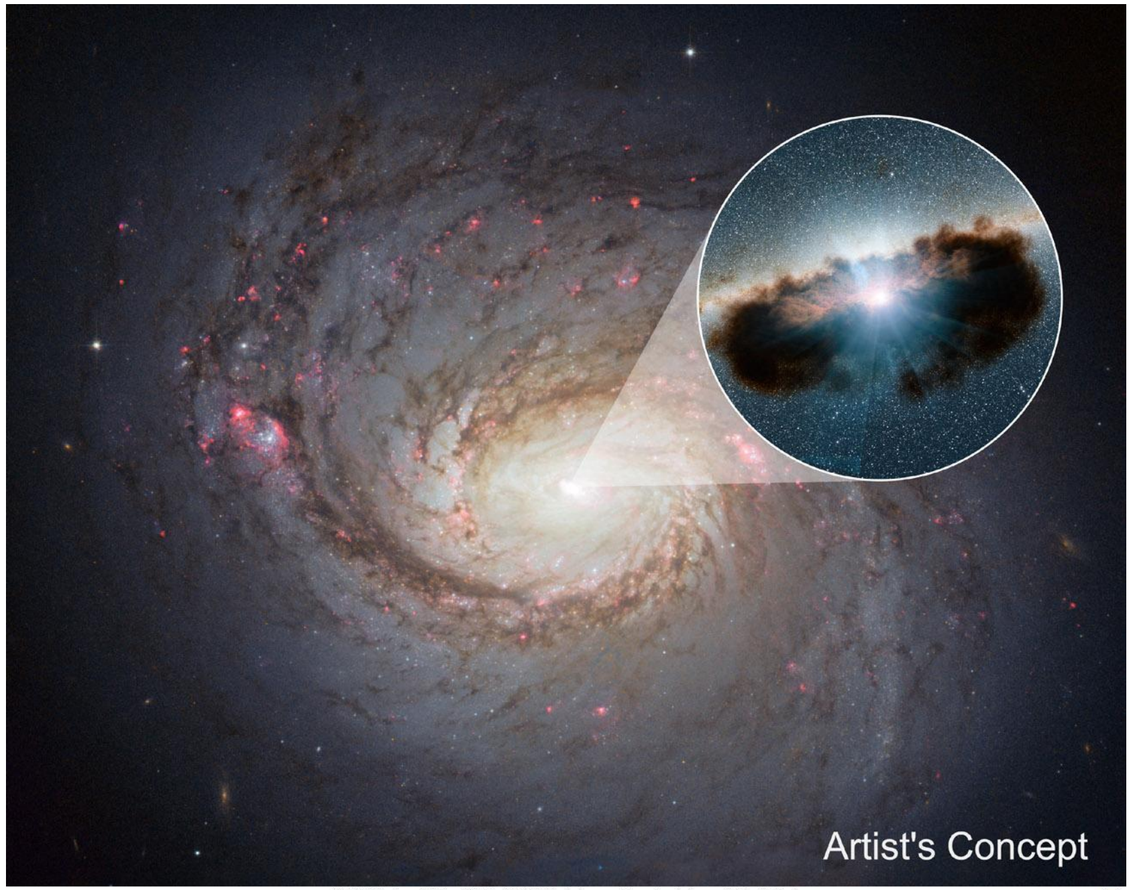
The most rapid black hole growth by accretion likely occurs in Compton-thick AGN at moderate redshifts

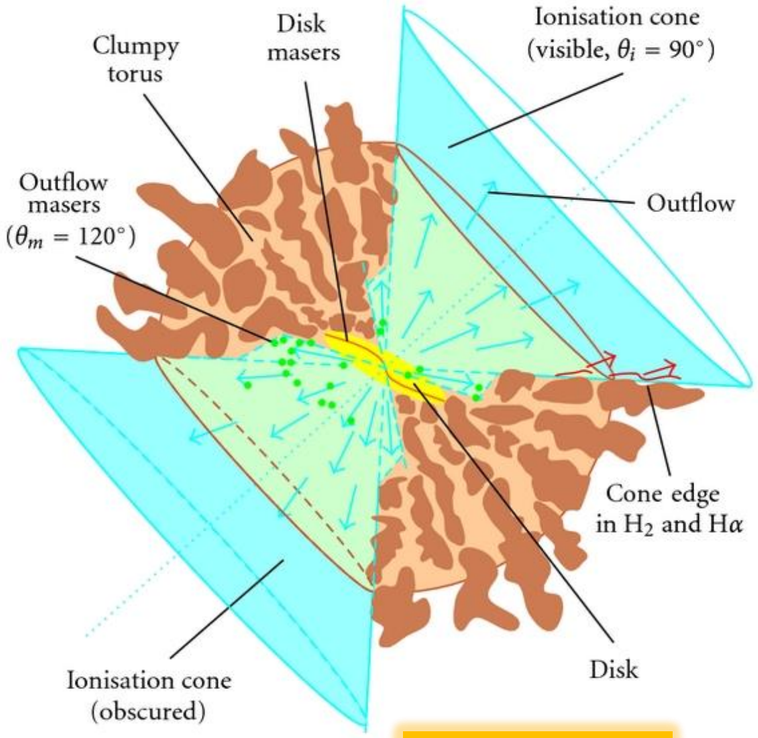
SMBHs may be accreting at potentially super-Eddington rates in these sources, which are therefore particularly important targets for our understanding of black hole and galaxy co-evolution



XMM-Newton joint with NuSTAR find clumpy Doughnut Around Black Hole

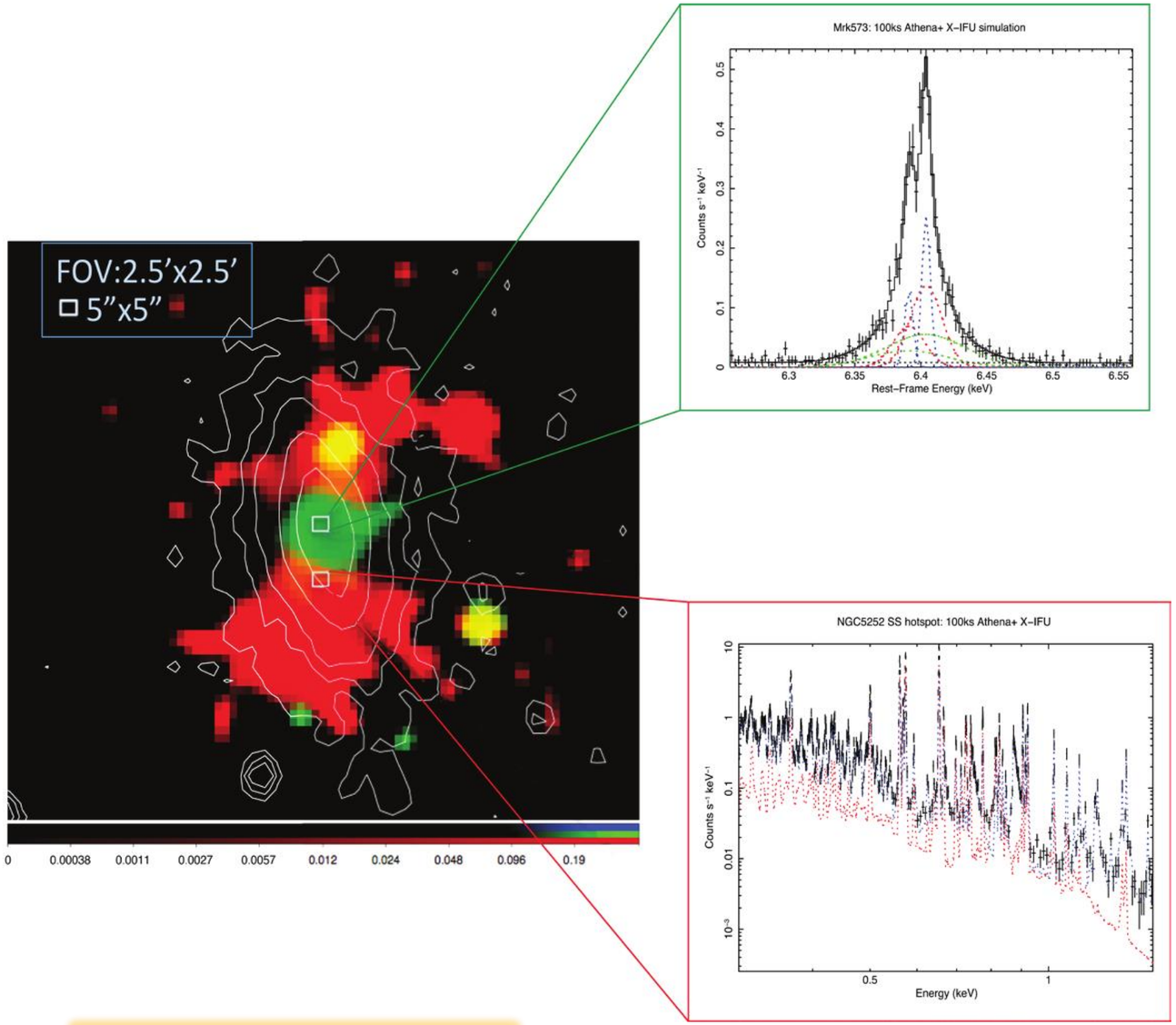
European Space Agency

Credit: ESA/XMM-Newton, CC BY-SA 3.0 IGO



Tristram+ 2007

CT AGN are also spectacular laboratories to investigate the reprocessing components from the **circumnuclear matter** around SMBHs, since the primary emission is suppressed



[#Athena Nuggets 48]
(Adapted from Cappi+ 2003)

The radiation emitted by the accretion disk interacts with the surrounding gas and gets 'reprocessed'

In particular, photons can be absorbed and re-emitted by atoms, giving rise to **spectroscopic lines**. The detailed analysis of the energy, strength and profile of these lines allows for a wealth of information on the **physical, chemical and kinematical properties of the gas**

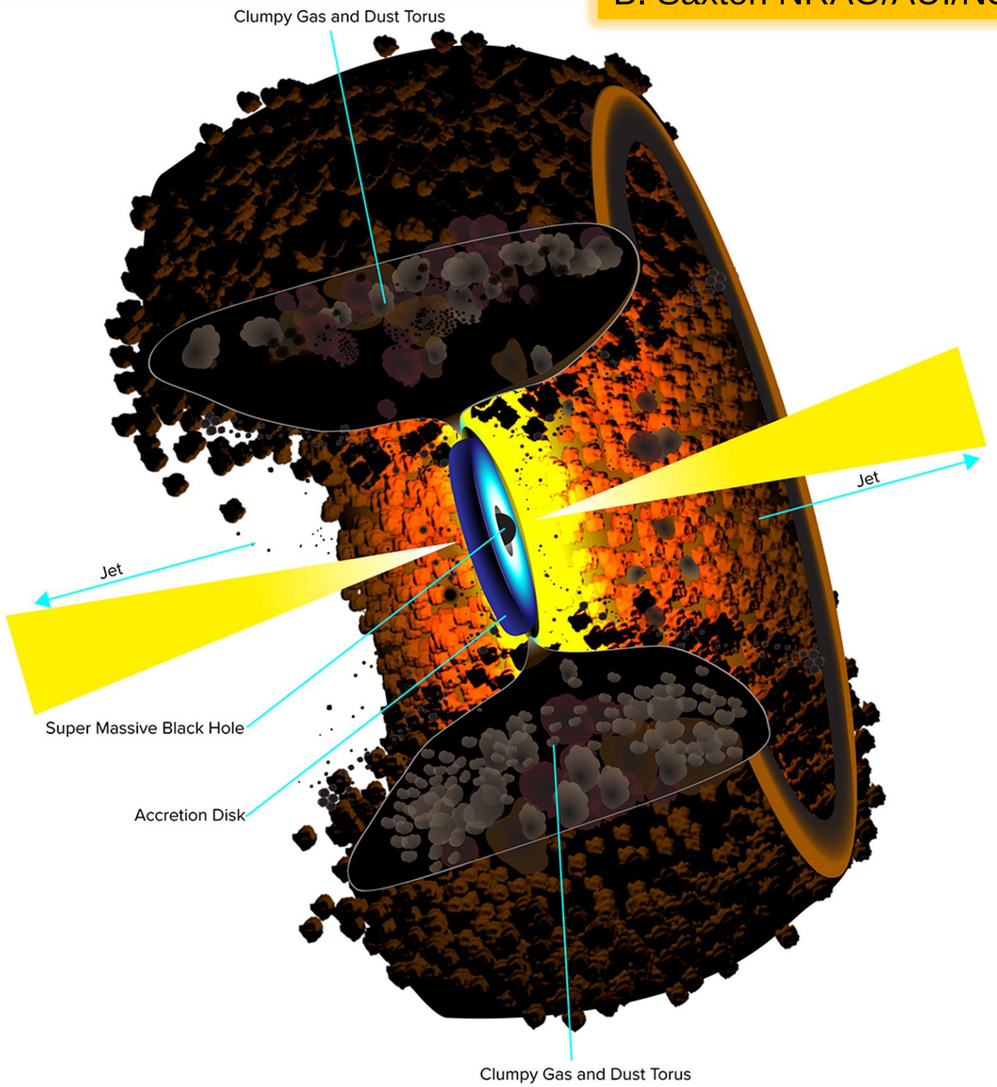
X-ray emission is a characteristic signature of AGN, and uniquely allows us to pierce the inner regions close to SMBHs.

However, **current X-ray data generally suffer from intrinsic limitations on spectral or spatial resolution, on collecting area or timing capabilities**

In order to break the symmetry of the polarization angles, the absorber should prevent the nuclear light to be scattered in a significant range of angles, and a ***torus*** is the most natural configuration that can achieve this effect

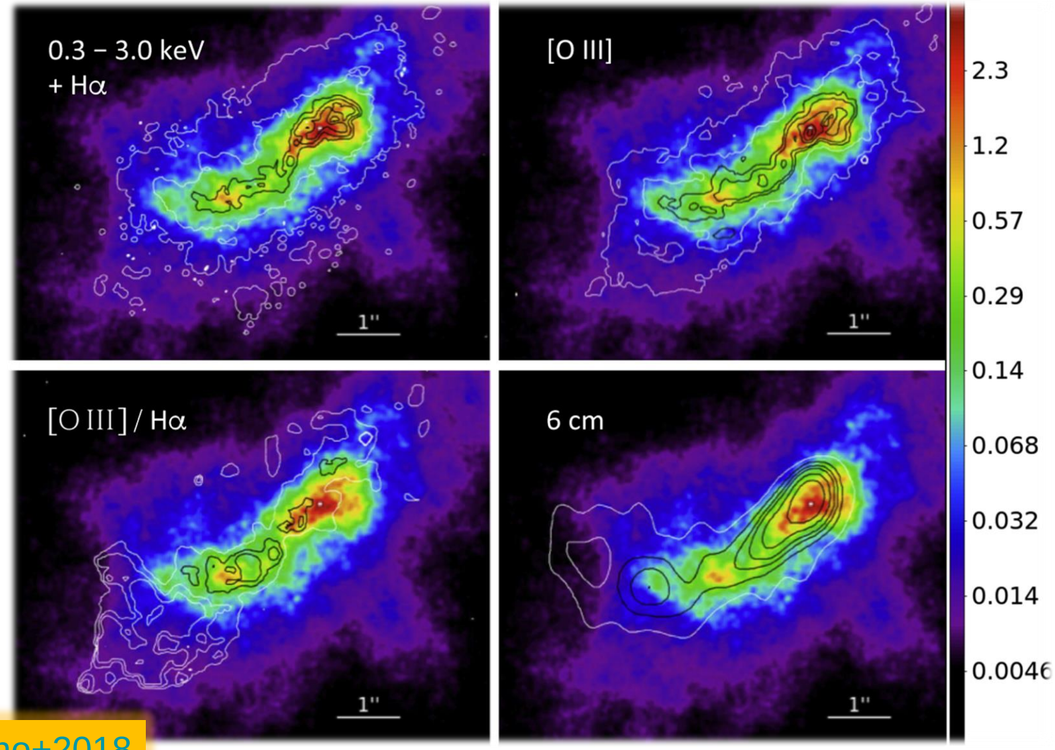
The size of the torus was initially postulated to be on the **pc scale**: large enough to obscure the BLR, but small enough not to obscure the NLR
However, **there is clear evidence that the absorbing medium is also distributed on smaller and larger scales**

The hypothesis of uniform gas and dust distribution has been abandoned by many models, by introducing a **clumpy structure of the absorbing medium**



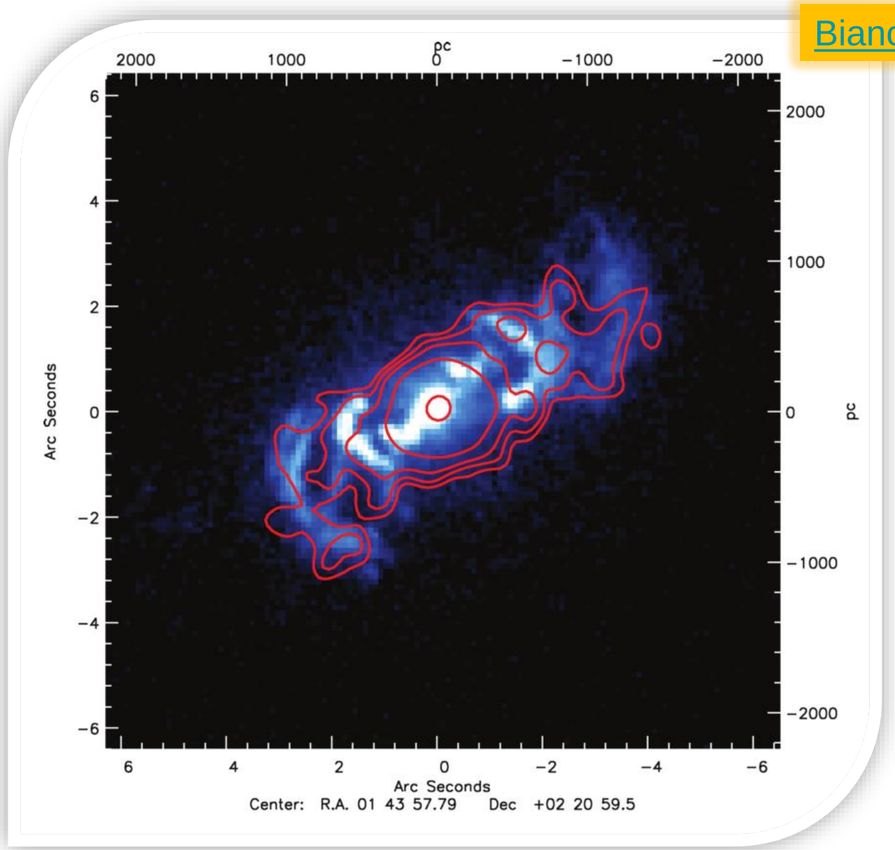
B. Saxton NRAO/AUI/NSF

The coincidence between the **soft X-ray and [O III]** emission is striking in most obscured AGN observed by *Chandra* and *HST*, both in extension and in morphology (e.g., Bianchi+, 2006)



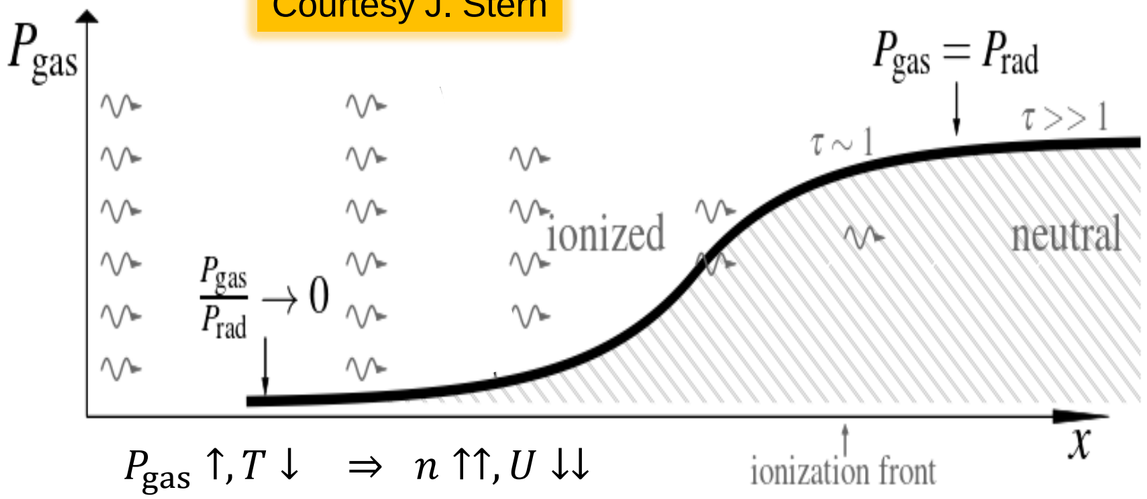
Fabbiano+2018

Bianchi+2010



The same gas, photoionized by the AGN continuum, and extended on $\sim 100s$ pc, **produces both the soft X-ray emission lines and the NLR optical emission**

Courtesy J. Stern

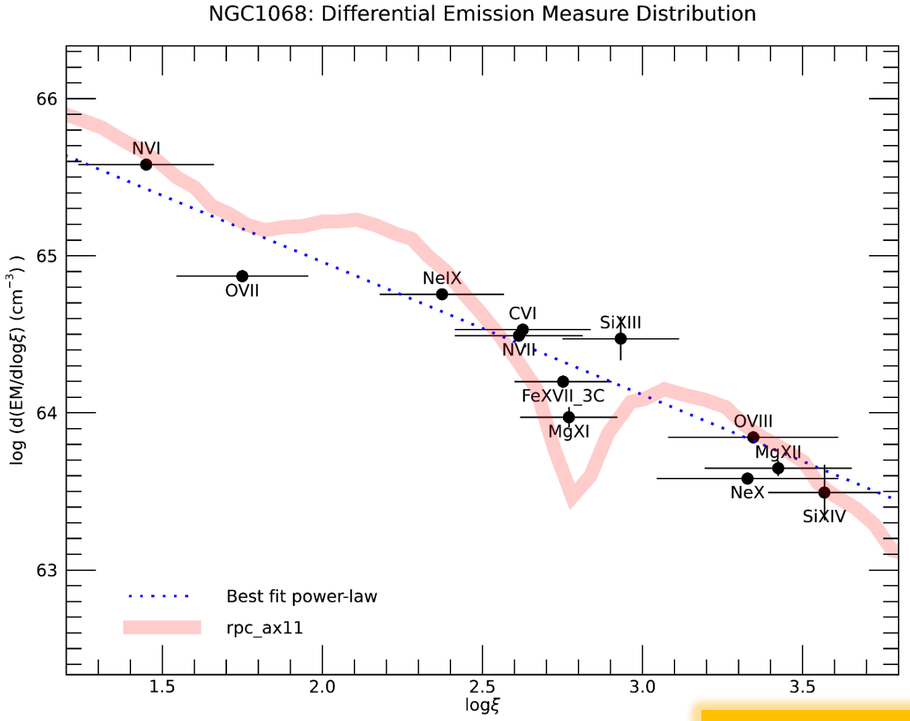


In an optically thick cloud illuminated by a source of photons, a gas pressure gradient must arise to counteract the incident ionizing radiation pressure

The gas is Radiation Pressure Compressed

The observed soft X-ray Differential Emission Measure distributions of obscured AGN are in remarkable agreement with the predicted universal DEM for RPC

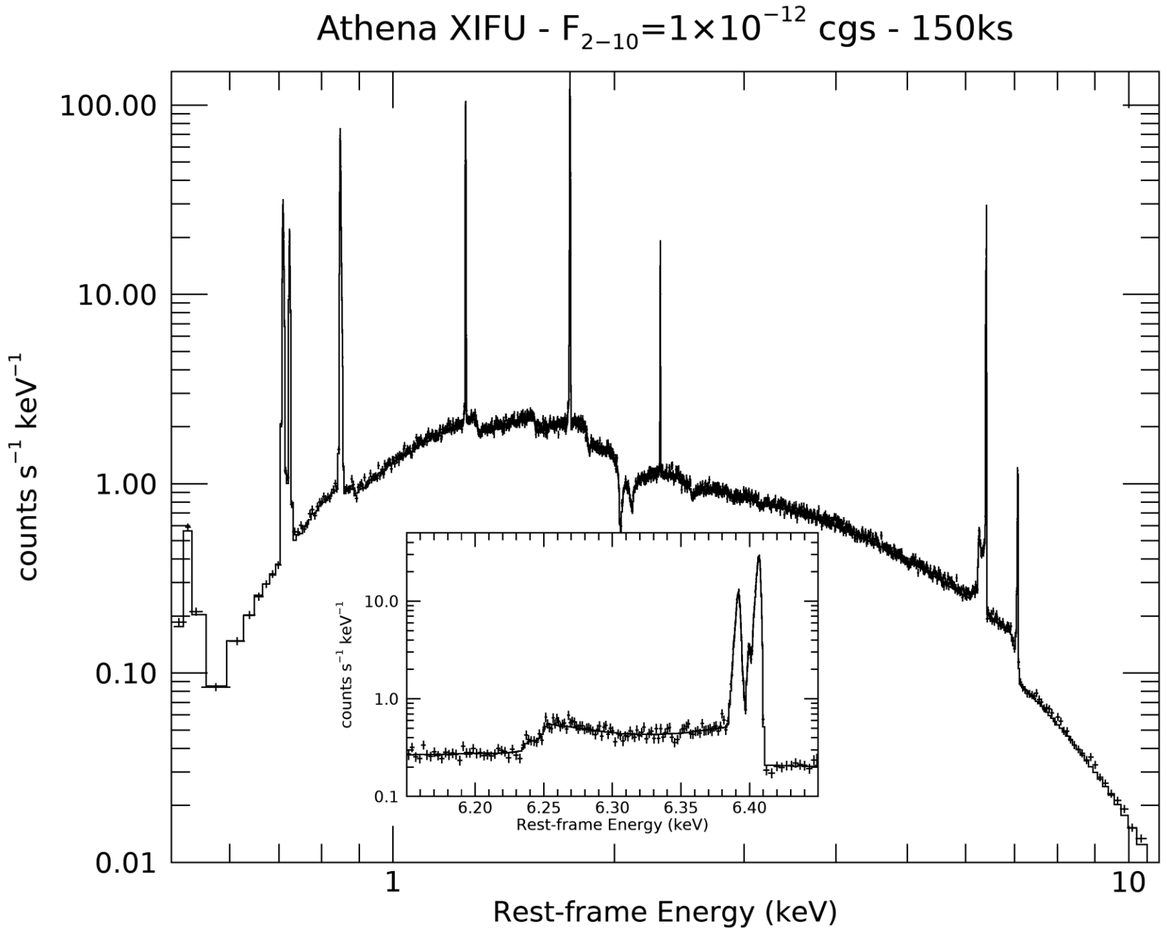
A constant gas pressure multiphase medium is not ruled out, but it is based on the false assumption that radiation pressure is negligible, and the universal slope of the observed DEMs is not a natural consequence as in RPC



Bianchi+2019

Several available models reproduce the reprocessed emission from Compton-thick matter

However, most of them use limited atomic databases and/or have an energy spectral resolution unsuitable for microcalorimeter spectra



STOKES
Modeling Radiative Transfer and Polarization

http://astro.u-strasbg.fr/~marin/STOKES_web/index.html

Marin+2018

STOKES is a Monte Carlo radiative transfer code in a wide three-dimensional environment. The code accounts for all the physics of scattering, absorption, and re-emission from the near-infrared to the hard X-ray band
It allows for different geometries and can be coupled to photoionization codes to handle also ionized matter
High energy resolution XSPEC tables can be easily created to fit *Xrism* and *Athena* spectra

As well as from the overall broadband continuum shape, **key parameters of the gas can be recovered with a detailed analysis of the properties of the emission lines**

Cloudy & Associates

Photoionization simulations for the discriminating astrophysicist since 1978

Ferland+2017

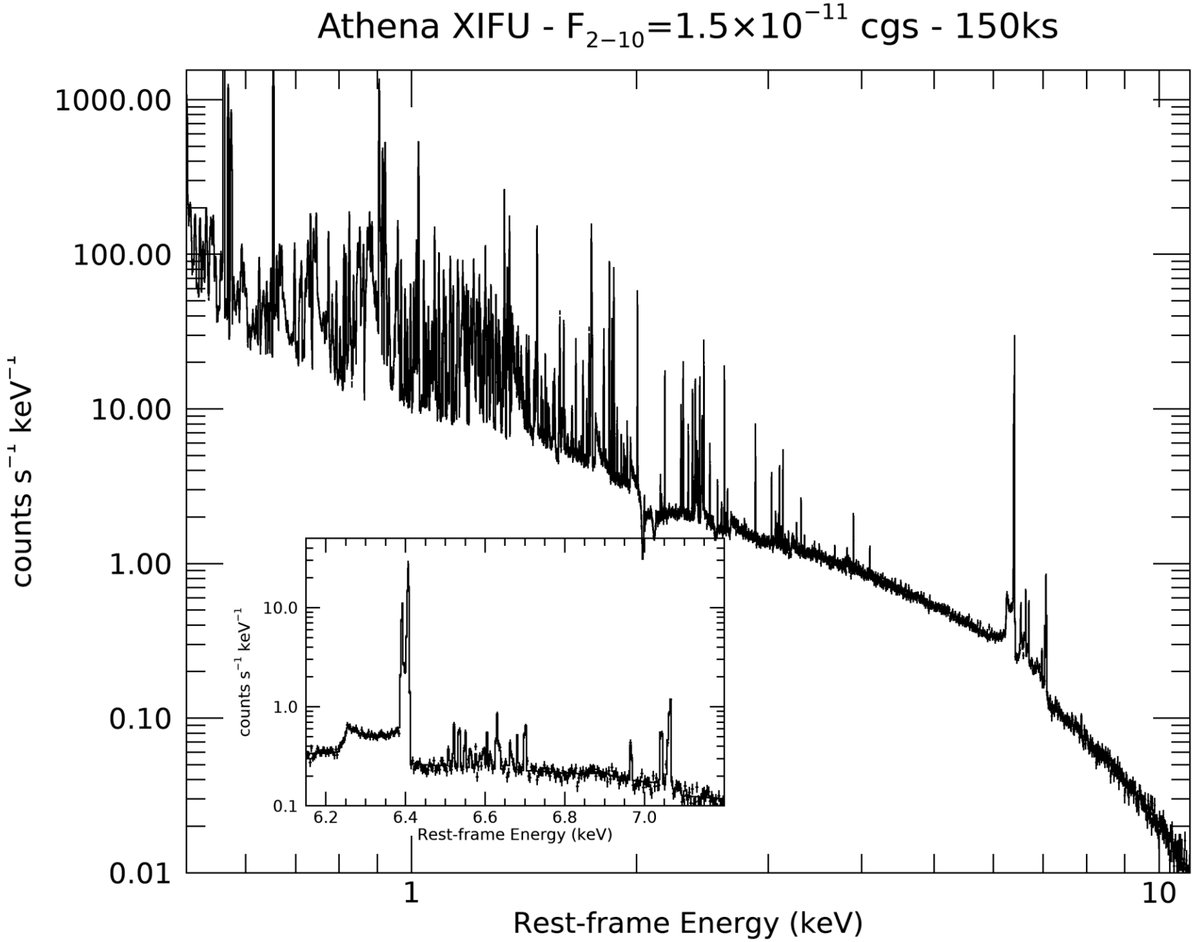
https://gitlab.nublado.org/cloudy/cloudy/-/wikis/home

CLOUDY is a spectral synthesis code designed to simulate conditions in interstellar matter under a broad range of conditions (CIE, PIE, RPC)

High energy resolution XSPEC tables can be easily created to fit *Xrism* and *Athena* spectra

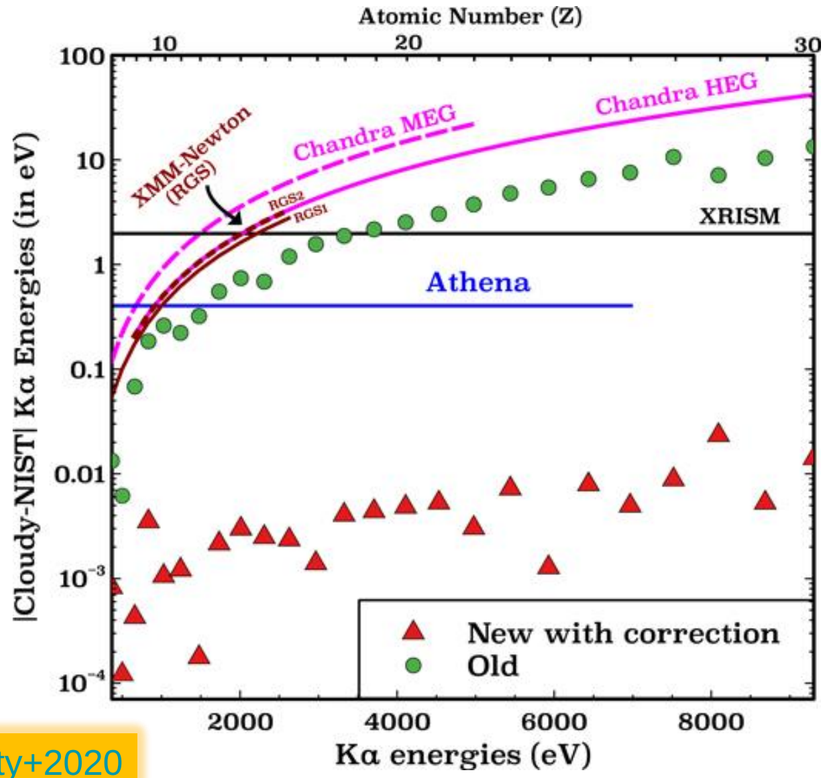
They will allow to measure physical, chemical and kinematical properties of the highly ionized gas in CT AGN, to disentangle the contribution from star-forming regions or shocks due to jets

For example, **RPC predicts an increasing gas pressure with decreasing ionization, which can be tested XRISM and Athena, using density diagnostics**



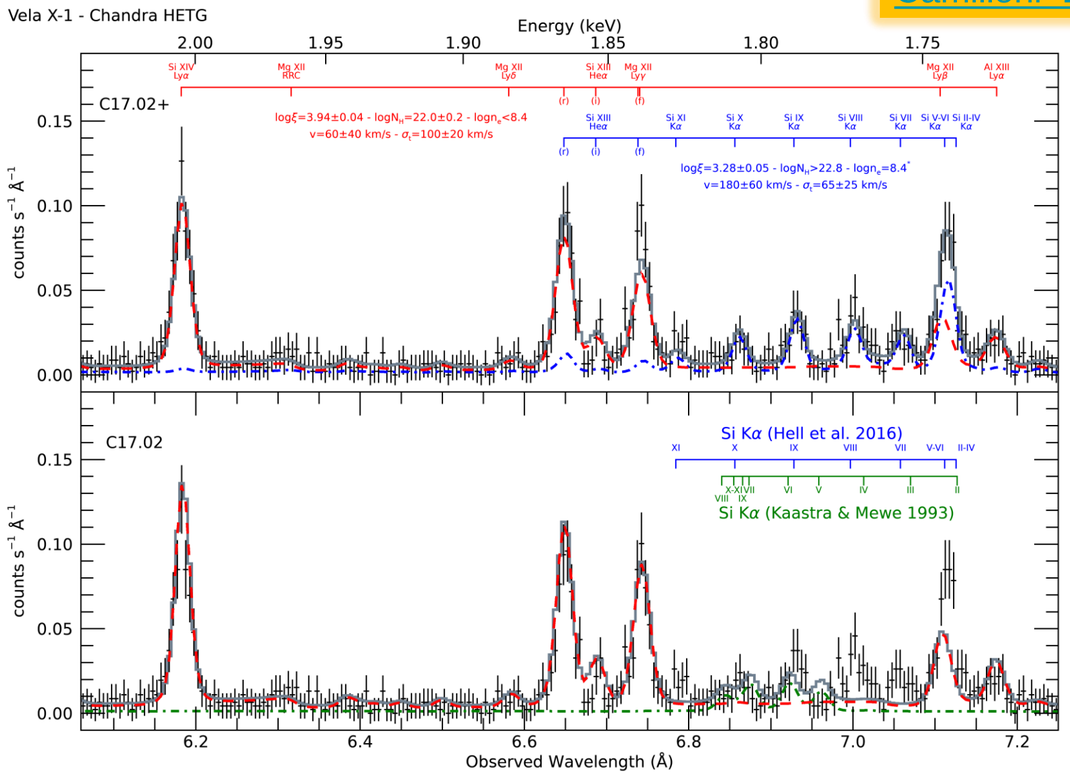
The upcoming X-ray missions based on the microcalorimeter technology require exquisite precision in spectral simulation codes in order to match the unprecedented spectral resolution

We have started a process to update the spectral simulation code Cloudy (Ferland et al. 2017), in order to keep up with these new spectroscopic requirements



Chakraborty+2020

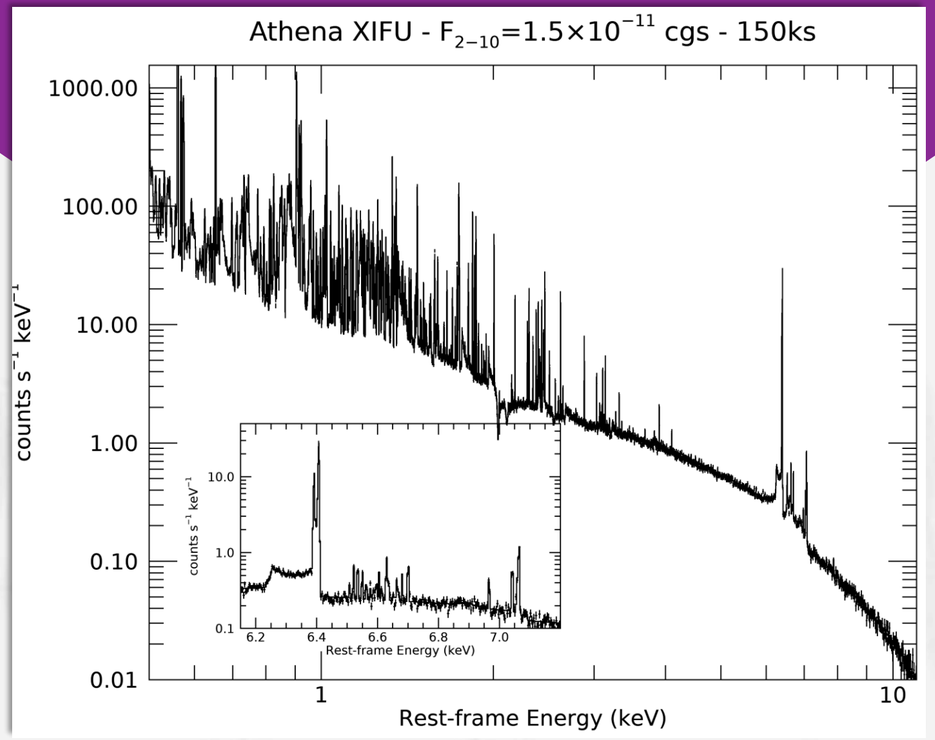
Camilloni+2021



Systematic efforts are in progress for other codes and for new laboratory measurements

It is crucial to be ready when the data will be available!

“XRISM and Athena/X-IFU will allow us to disentangle all the spectral components of CT AGN, and to probe effectively fainter sources at higher redshift, enabling a real breakthrough in this field.”



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