Supermassive Black Hole Winds in X-rays

M. Brusa[1,2] & G. Lanzuisi[2] on behalf of the SUBWAYS team

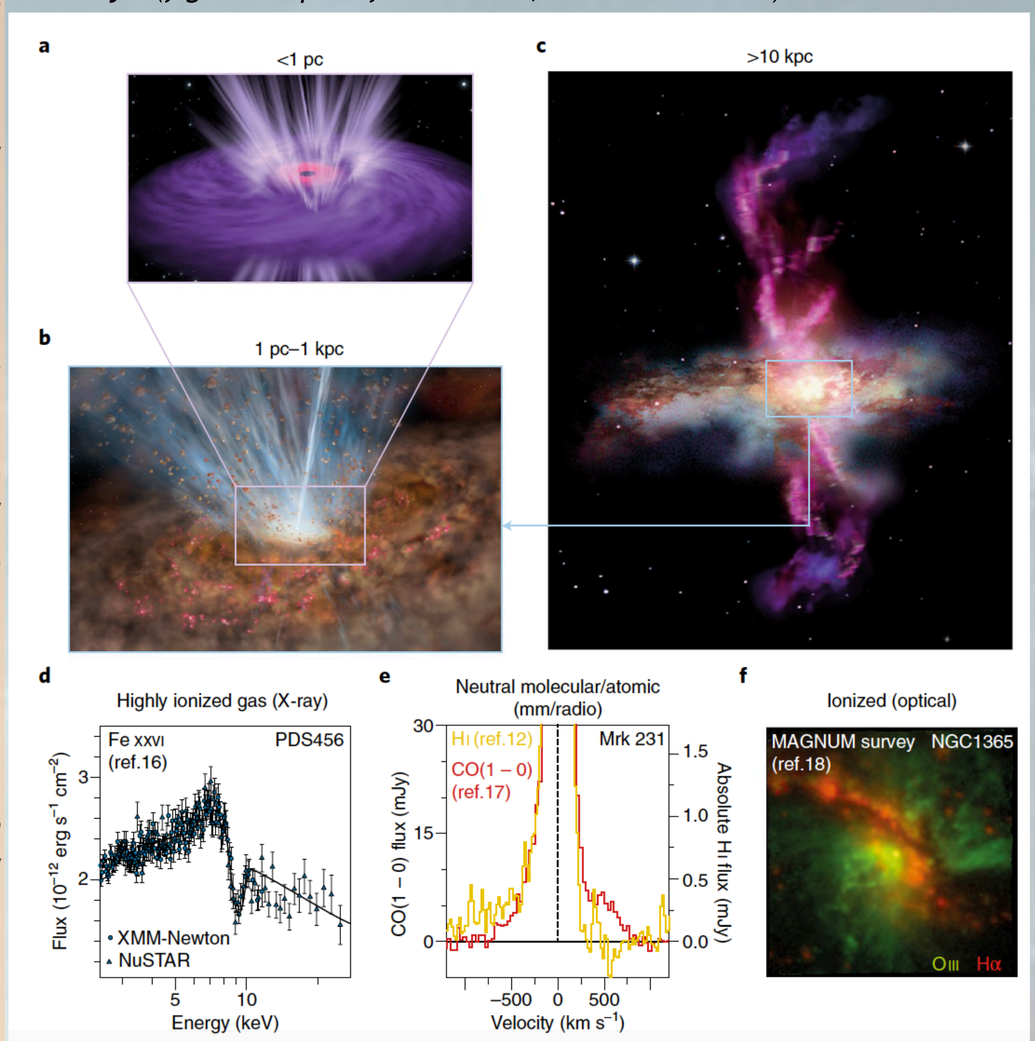
(1) Dipartimento di Fisica e Astronomia Università di Bologna; (2) INAF-Osservatorio di Astrofisica e Scienza dello Spazio di Bologna

https://marcellabrusa.wixsite.com/subways2019/team

(1) RATIONALE:

It has been proposed that gas flows in the form of energetic winds may play a pivotal role in galaxy evolution (e.g. King & Pounds 2015, ARA&A 53, 115):
1) their **presence regulates both accretion and ejection of material** onto and from the Supermassive Black Holes (SMBH, 10^6-10^{10} M_{sun}) sitting in the nuclei of virtually all galaxies;
2) the **gas accelerated by the radiation pressure from the accretion disc** in sources accreting near the Eddington limit **interacts with the host galaxy Interstellar Medium (ISM)**, propagating momentum and energy and providing an efficient feedback mechanism (e.g. Zubovas & King 2012, ApJ 745, L34).
The outflows developing in AGN host galaxies have a multiphase nature, as revealed by observations and expected from simulations (Cicone+18, Nat. As. 2, 176; see Figure 1*)*. Theoretical models ascribe an important diagnostic role to **relativistic hot, ultrafast outflows (UFOs)** produced by the innermost gas close to the accretion disk (<1 pc) that first feels the pressure from the AGN radiation field. These winds are detectable through **strongly blue-shifted absorption lines associated with highly ionized iron atoms** (Fe xxv and Fe xxvi) observable at energies E>6 keV (e.g. Tombesi+10, A&A521, A57).
From an observational point of view, the characterisation of UFOs in terms of physical properties (e.g. mass outflow rates, duty cycle) and their incidence in relation to the AGN properties has been mainly carried out so far through studies based on archival data, focusing mainly on two cosmic epochs and two luminosity regimes (Figure 2 upper panel; z<0.1 and z>1).

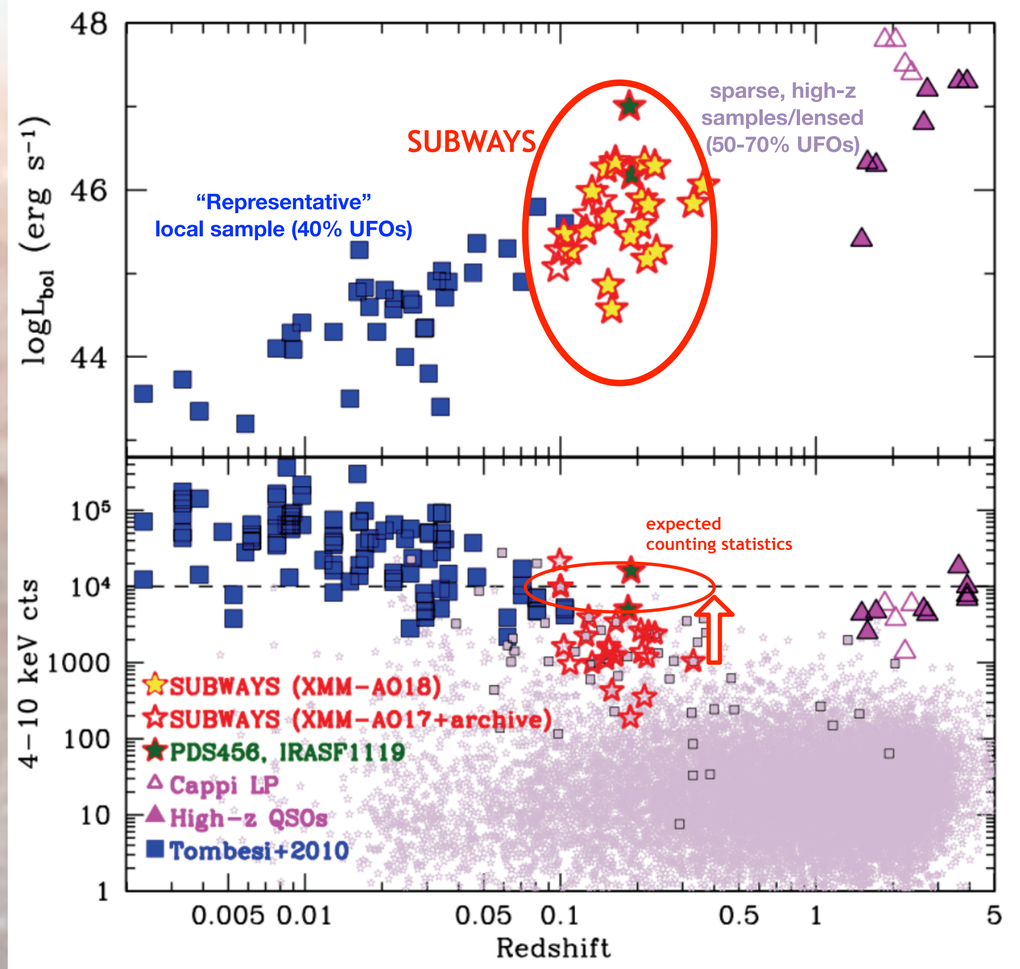
Figure 1: *Artistic view of multiphase AGN-driven winds highlighting the different phases and scales that are involved in the outflow. The wind propagates from the central engine (< 1 pc; a), through the surrounding ISM (1 pc-1 kpc; b), out to the boundaries of the host galaxy (> 10 kpc; c). SUBWAYS will investigate the outflow in its launching phase, when the gas is highly ionized, and the presence of fast moving material can be revealed in X-rays. (figure adapted from Cicone, Brusa et al. 2018)*



(2) SUBWAYS PROJECT

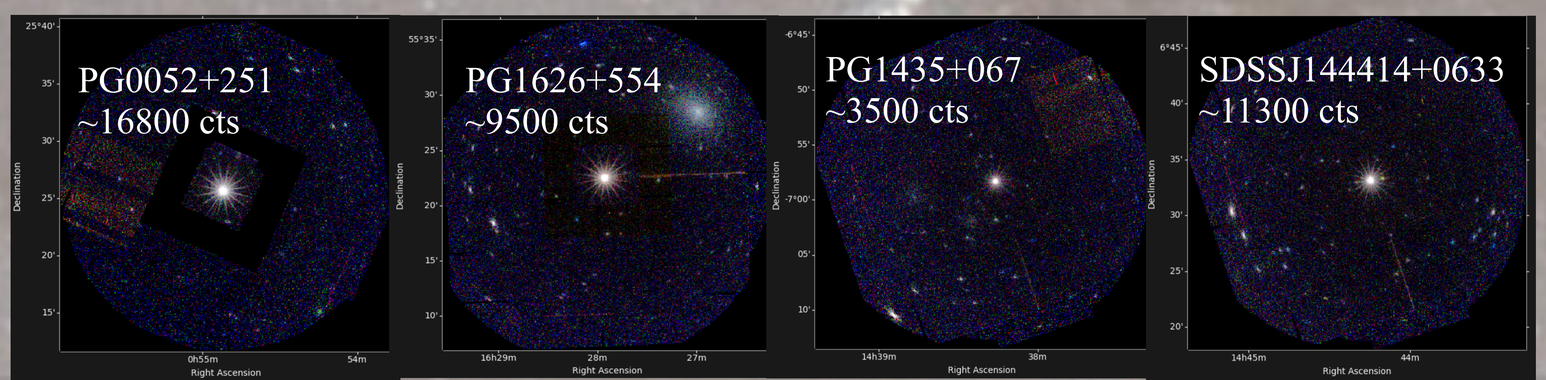
In order to shed light on the role of UFOs and winds in galaxy evolution, we **have been awarded a Large Program of ~1.6 Ms with XMM-Newton in AO18,** SUBWAYS ("Supermassive Black Hole Winds in X-rays"). This is the the *largest program ever approved in a single XMM-Newton cycle in the scientific category "Active Galactic Nuclei, Quasars, BL-Lac Objects and Tidal Disruption Events" over 20 years.*
SUBWAYS has been designed to provide a **direct test of QSO feedback models** via observations of **~25 sources at z=0.1-0.5 and L_{bol}>10^{45} erg/s,** carefully preselected from existing XMM-Newton archival snapshot observations. This enabled us to envisage an **observational strategy to obtain X-ray spectra of unprecedented quality** (~10.000 net counts in the rest-frame 4-10 keV, comparable to that obtained for local Seyferts; see Figure 2 lower panel). With such high ounting statistics will obtain homogeneous characterisation of UFOs properties in a luminosity and redshfit range not yet explored, and perform robust measurements of the underlying physical parameters (e.g. ionization parameter, velocity vout, column density NH, covering factor) needed to constrain models.
SUBWAYS represents the **indispensable step** needed to subsequently investigate the appearance of outflows phenomena across various galaxy scales, gas phases and wavelengths. We already secured **27 HST orbits** in cycle 27 (PI:G. Kriss) to obtain COS spectra and cover all strong UV lines, and we plan to extend the multiwavelength coverage in the optical (MUSE), millimeter (NOEMA, ALMA) and radio (JVLA) bands, as well as at higher X-ray energies (NuSTAR).

Figure 2: *The luminosity (upper panel) and rest frame 4-10 keV counts (lower panel) plotted against redshift for the ~25 SUBWAYS targets (red symbols, including our own observation of PG1402+261) and those to be observed in XMM-AO18 (19 targets; yellow symbols). We also show sources in the comparison samples already available in the literature (blue and magenta symbols, at z<0.1 and z>1, respectively), as well as the SUBWAYS parent samples (PG QSO sample and 3XMM sample, violet squares and points).*



(3) STATUS OF THE XMM-NEWTON OBSERVATIONS

Observations started in May 2019 and **4 sources** have been observed and PPS processed so far. The PPS images in the 0.2-12 keV band, obtained combining MOS1, MOS2 and pn are shown below, along with the detected net counts in the 4-10 keV band, on average in very good agreement with our estimations!



(4) WE WANT YOU!

Next month we will open a position at DIFA & INAF-OAS on data reduction and analysis of the XMM-Newton SUBWAYS observations *(funded by ASI from the agreement ASI-INAF n.2017-14-H.0)*

STAY TUNED & APPLY!