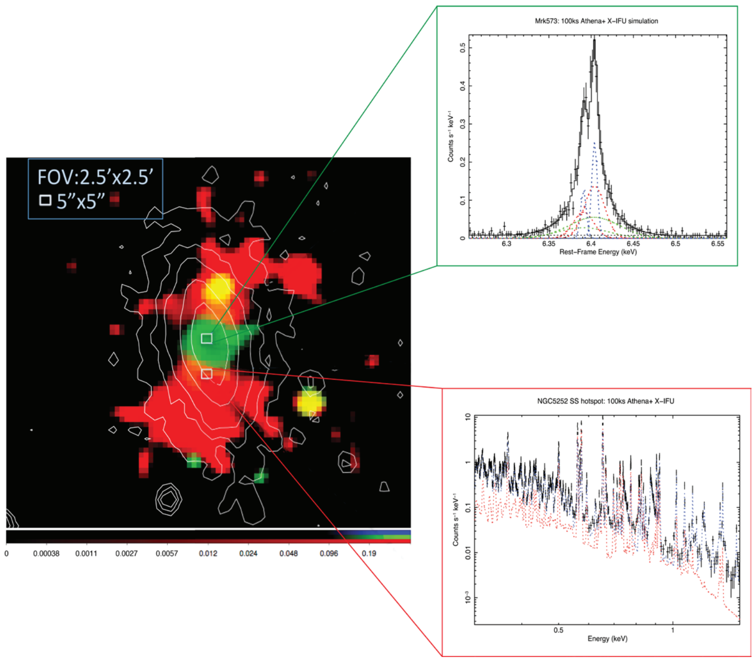
Mapping the Surroundings of Supermassive Black Holes

Stefano Bianchi
Università degli Studi Roma Tre
Italy



Left: Athena simulated color-coded image of a nearby Seyfert 2 a typical X-ray obscured AGN. The soft X-rays (red) trace a biconical outflow driven by the AGN which impacts all over the host galaxy (indicated by the white contours). Right-top: Athena simulated profile of the iron fluorescence line arising from different regions around the SMBH: the X-IFU high spectral resolution allows for the separation of all components. Right-bottom: X-IFU simulated spectrum of a part of the plume of ionized emission south of the nucleus: the contributions from shocked thermal emission and gas photoionized by the AGN can be clearly separated. Figure adapted from Cappi et al. (2013).

Supermassive black holes (SMBHs hereafter) are ubiquitous in the center of galaxies, including our own Milky Way. Although their gravitational sphere of influence is tiny with respect to that of the total mass of their hosts, their overall impact on the evolution and growth of galaxies is thought to be crucial. This 'feedback' arises when the SMBH accretes matter, becoming an 'Active Galactic Nucleus', or AGN. The matter falls into an 'accretion disk' orbiting the SMBH while converting its gravitational energy into radiation, jets and outflows, which then interact with the surrounding environment from nearby to galactic scales and beyond. A detailed mapping of the neighborhood of SMBHs would represent a huge leap forward in our understanding of the accretion flow around AGN and their key role in shaping the Universe as we know it.

The radiation emitted from the inner parts of the accretion disk around the SMBH interacts with the surrounding gas and gets 'reprocessed', leaving tell-tale imprints in the process. In particular, the 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 which produces them. X-ray emission, in particular, is a characteristic signature of AGN, and a characteristic signature of AGN, and a unique probe of the inner regions close to SMBHs. Indeed, current and past X-ray observatories have provided an enormous amount of information about accretion flows around AGN and their impact on the host galaxies. However, these data have suffered from intrinsic limitations in the telescope's sensitivity or spectral, spatial, or timing resolution.

Athena will provide a real breakthrough in this field, thanks to the exceptionally high energy resolution and collecting area of the X-IFU, which can be combined with its powerful imaging and timing capabilities. For example, it will be possible to disentangle the velocity profiles of the components of emission lines arising from different regions around the SMBH, together with their distance and geometric arrangement as determined via direct imaging or reverberation mapping. Another exciting possibility would be to quantify the effects of shocks induced by jets or outflows on different scales of the galaxy, in order to see feedback 'in action'. The space for discovery is huge: the surroundings of SMBHs will be investigated as never before.