Astrophysical black holes are extremely simple objects: they are fully described by their mass and spin. Accretion is the physical process that makes black holes "visible" to our detectors. It results from gravitational attraction of matter, which emits radiation (namely light) while falling onto the black hole. This radiation is the result of the accreted matter being heated up by the relative friction, resulting in the emission of an enormous amount of energy. The closer to the black hole, the higher the energy of the emitted radiation, up to the X-rays, which are the signature of matter orbiting close to the black hole event horizon.

The main goal of researchers studying accreting black holes is to indirectly derive the properties of the accreted gas and the physical parameters of the black hole by studying radiation emitted by these systems. Indeed any accreting black hole and its flow of accreted gas are so tiny in the sky that we cannot directly image them.

Understanding how these powerful engines work is of great importance, because the amount of radiation they emit has a great influence on the properties of the environment they live in: some amongst the biggest black holes (with a "radius" about the distance between planet Earth and the Sun) are so powerful they regulate the evolution of the entire galaxy that hosts them!

Though being observed and studied for almost 5 decades, the mechanisms regulating black hole activity are still a mistery. In particular, the way the gas which is about to be accreted distributes itself while orbiting close to the black hole is not well understood. There are indeed several possible configurations, the main one being a disc that extends down to the closest orbit around a black hole. Understanding what is the real configuration is necessary in order to derive correct measurements of the black hole parameters, and to understand why these compact objects can form powerful jets of expelled matter, whose size can be several times the diameter of the host galaxy.

Finding an effective method to measure the geometry of the accreting gas close to the black hole is thus fundamental. Fortunately the amount of radiation accreting black hole systems emit is variable over time. This means that we can measure huge fluctuations of the emitted radiation occurring over a time span of a few minutes for the biggest black holes, or even of 1/100 of a second for the smallest ones. Another fortunate circumstance is that the emitted radiation can interact with the accreted gas itself, which can act like a mirror, reflecting the irradiating variable radiation. Since the speed of light is finite, the result is that the reflected radiation will show fluctuations as well, but delayed with respect to the fluctuations seen in the emitted radiation which reaches the observer directly. The time delay is due to the extra path the reflected light has to travel before reaching the observer and is directly linked to the distance between the primary source and the reflecting gas. This method is called "reverberation" and constitutes an effective way to directly measure relative distances and thus to extract information on the geometry of the accreting gas.

The advancement of technology has allowed us to put detectors onboard X-ray space telescopes able to capture very fast fluctuations of the emitted radiation as well as the response of the irradiated gas situated very close to the black hole.

Through this project we endeavour to use the "reverberation" method to map the close environments of accreting black holes. This is a fundamental step towards building a complete knowledge of the behaviour of matter at the extremes of space and time.