The X-ray Facility of LNF
XLab Frascati

X-ray, light and electromagnetic radiation

At the end of the XVII century, Newton discovered that the “white” light originated from the Sun is a mix of several fundamental colors (each associated with various frequencies). With his experiments he was able to separate the different colors, observing a regular distribution which he named a *“spectrum”*. This was the first observation of the electromagnetic spectrum, where all radiations were classified by their *“size”*, the wavelength.

Years later, it was proved that first discoveries were related only to a small portion of the radiation world: the spectrum became much more extended, with “bigger” and “smaller” waves out of the interval of the visible light.

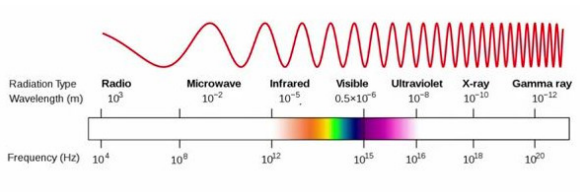

Fig.1 - Electromagnetic Spectrum

X-ray: a Nobel Prize Radiation

At the end of the 19th century, while all over the world various scientists were actively studying various peculiarities of the interaction between radiation and matter, Wilhem Röntgen observed experimentally an unknown radiation, which was for this reason called “X”. The 1895 thus became the year of one of the most important human discoveries, written in the pages of history as the discovery of X-rays. The first radiography, namely “X-ray radiography”, obtained thanks to this unknown emission whose origin was afterwards completely explained, earned Röntgen the first Nobel Prize for Physics in history. Since then 15 Nobel prizes were assigned for research related to the X-rays, the latest in 1988.

Nowadays, X-rays are known as an electro-magnetic radiation characterized by a wavelength ranging from ten nanometers (corresponding to one millionth of centimeter) to one thousandth of nanometer. This particular dimension, very close to the characteristic size of atoms, makes X-rays especially suitable to the study of matter and its properties: information concerning the crystalline state, inner structures and elemental composition of materials are provided by the employment of different X-ray based techniques, currently known as X-ray diffraction, X-ray fluorescence, X-ray imaging, etc. X-ray analysis, by means of specific instruments, finds its application in many different fields of research, from the basic research in physics, to chemistry, biology and medicine, up to engineering and industrial innovations.

Fig.2 – Pictures of XLab

XLab Frascati

This laboratory was established as a result of the activity of research and development of national and international projects concerning X-ray optics, especially polycapillary optics. But it’s in the year 2010 that XLab Frascati was officially inaugurated.

The main activity of the XLab researchers is focused on X-ray analysis by means of desktop techniques, mostly based on polycapillary optical elements, and on theoretical studies on charged and neutral particles interactions in different fields, especially concerning *channeling*, field of physics that studies the path of charged particle or electromagnatic radiation inside regular structure such as crystals.

The laboratory equipment serves to a number of purposes: analysis of micro-macro X fluorescence (traditional, confocal, total external reflection) applied on Cultural Heritage and Geological samples; X-ray diffraction applied to the examination of materials; temporary experiments and testing systems for

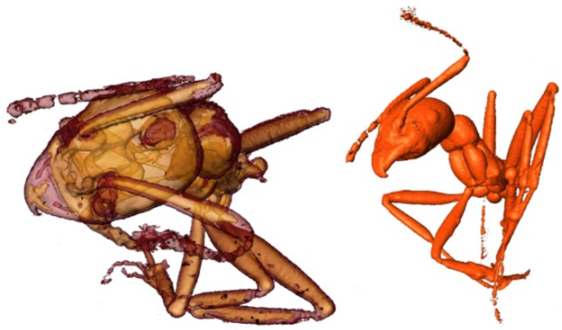

Fig.3 – 3D rendering and internal structure af an Ant obtained by X-Ray Tomography

the design of new detectors; study of imaging techniques and X tomography projects.

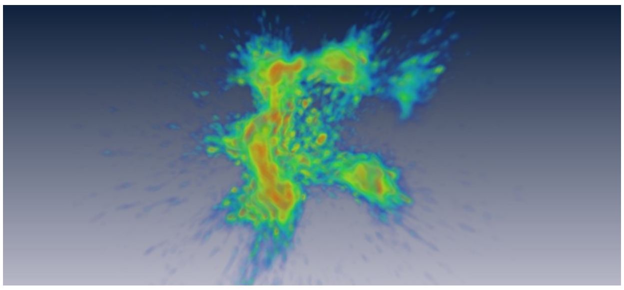

Fig.4- 3D Rendering of Gasoline Spray of engine's injection devices obatained by Fast X-ray Tomography

Recently, the experimental progresses of the Laboratory have been focused on low contrast samples analysis, like biological specimens (Fig. 3) and injection sprays from engine’s injection devices (Fig. 4).

Polycapillary Optics

XLab Frascati sets at the center of its research activity the study and characterization of particular X-ray optics: the polycapillary lenses. Invented in 1984, these lenses are based on the phenomenon of total external reflection of the X-rays inside them. The lens are composed of millions of glass channels, in which the

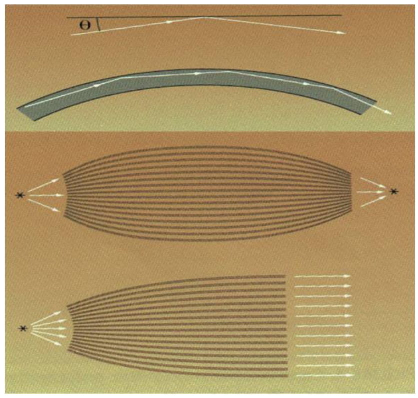

Fig.5 - Scheme of Polycapillary Lenses

entering radiation is efficiently transmitted by multiple reflections.
This way, it's possible to collect the divergent radiation, focusing it or converting it into a parallel beam, hence allowing to model the beam as needed, for instance addressing another flux of X-rays on research samples.
This behavior opens up the possibility of building a brilliant X-ray source with performances comparable to those of the synchrotron light combining a conventional X-ray tube and polycapillary optics.

Projects and collaborations

The term “X” in the XLab abbreviation doesn't just indicate the name of the radiation, but it also represents a crossroad of interactions: XLab Frascati is involved in a number of projects (UA9-LUA9, GEMINI, POSSO, MicroX, POLYX, NANORAY, GMINUS2) within collaboration programs (Universities, research Institutes and industrial partners) focused on shaping up charged and neutral particle beams by means of various techniques such as crystal channeling, channeling in laser and plasma fields, capillary/polycapillary optics.