

## X-ray: a Nobel Prize Radiation

At the end of the 19<sup>th</sup> century Wilhem Röntgen observed experimentally an unknown radiation, which was for this reason called “X”. The first radiography, namely “X-ray radiography”, 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 electromagnetic 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.



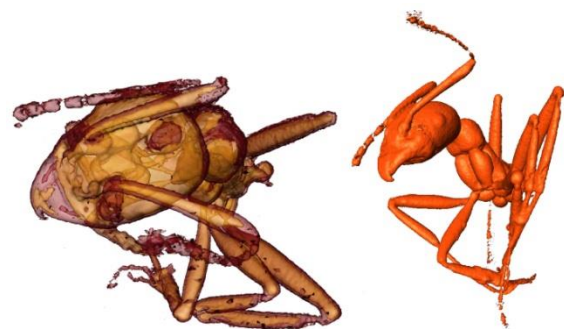
*Fig.1 – Pictures of XLab*

## 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.

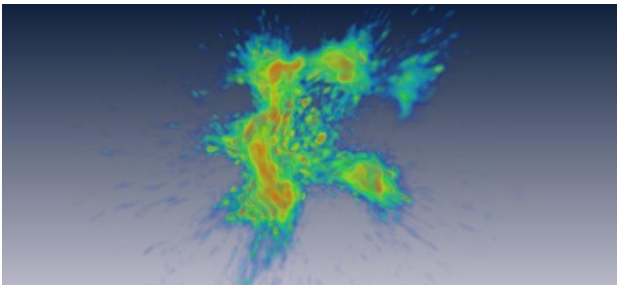
The main activity of the XLab researchers is focused on X-ray analysis by means of desktop techniques, mostly based on polycapillary optical elements, and on theoretical studies on charged and neutral particles interactions in different fields, especially concerning *channeling*, field of physics that studies the path of charged particle or electromagnetic 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 the design of new detectors; study of imaging techniques and X tomography projects.



*Fig.2 – 3D rendering and internal structure of an Ant obtained by X-Ray Tomography*

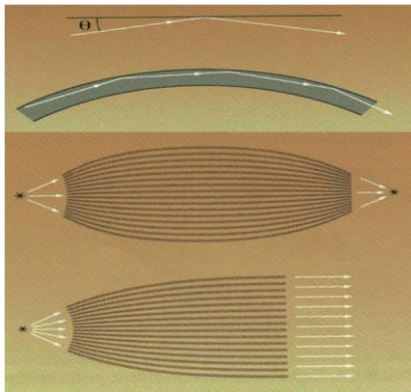
Recently, the experimental progresses of the Laboratory have been focused on low contrast samples analysis, like biological specimens (Fig.2) and injection sprays from engine's injection devices (Fig. 3).



*Fig.3- 3D Rendering of Gasoline Spray of engine's injection devices (Fast Xray Tomography)*

### 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 is composed of millions of glass channels, in which the entering radiation is efficiently transmitted by multiple reflections.



*Fig.4 - Scheme of Polycapillary Lenses*

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.

XLab is one of the few facility all over the world able to realize polycapillary optics. Within the INFN National Laboratory of Frascati is build the **Polycapillary Technopolo**, where the whole production chain, from fabrication to characterization, is followed.

At present the available optics are:

#### Dimensions optics:

- lenght: 30-50 SemiLens, 60-100 Full Lens
- Inlet/Outlet: 3-10 mm

#### Typologies

- Full PolyCO Lens
- Semilens PolyCO
- Straight PolyCO
- Full-Semi MonoCO lens
- Single Capillary (shaped - full, semi - straight)

#### Focal Data

Focal distance	30- 80 mm
Focal spot (Full Lens)	60-90 $\mu\text{m}$

#### Dimensions single channel

- 3-10  $\mu\text{m}$  (PolyCO IV Gen.)
- >20  $\mu\text{m}$  (MolyCO)

#### Energy range

- PolyCO IV Gen. -> 3-40 keV
- MonoCO -> 1-5 keV

#### Transmission

- 40-70% 8 keV (PolyCO IV Gen.)
- 20-40% 17 keV (PolyCO IV Gen.)

### 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.