3rd International Conference on Tomography of Materials and Structures
Lund, Sweden, 26-30 June 2017, ICTMS2017-163

NeXT-Grenoble, a novel facility for Neutron and X-ray Tomography in Grenoble

A. Tengattini *[1, 2], D. Atkins[2], B. Giroud[2], E. Andò[1], J. Beaucour[2], and G. Viggiani[1]

[1]Univ. Grenoble Alpes, CNRS, Grenoble INP †, 3SR, F-38000 Grenoble, France
[2]Institut Laue-Langevin, 71 Avenue des Martyrs, 38000 Grenoble

Keywords: neutron tomography, x-ray tomography, instrument, hydro-chemo-mechanical testing

Summary: NeXT-Grenoble is a Neutron and X-ray facility which is currently being developed in Grenoble, born from a collaboration between the Universite Grenoble Alpes and the Institut Laue-Langevin. This instrument combines the uniquely powerful neutron flux offered by the Institut Laue-Langevin with x-ray imaging, striving to achieve the simultaneity which will allow their complementarity to be exploited

1. INTRODUCTION

NeXT-Grenoble is a Neutron and X-ray Tomograph born in 2016 from the joint effort of Université Grenoble Alpes (UGA) and the Institut Laue-Langevin (ILL), and takes advantage of its world-leading neutron flux. Another key feature of the instrument will be the possibility to perform x-ray tomography as sketched in Fig. 1, in order to take advantage of the high complementarity of these two techniques.

Additionally, this instrument is conceived with both fundamental and engineering applications in mind as the in-situ chemo-hydro-mechanical testing of geomaterials.

This contribution reviews key aspects underlying the design of NeXT-Grenoble as well as some of the preliminary results coming from it.

2. THE INSTRUMENT

This instrument has recently completed the first phase of its commissioning: the ability to do medium resolution neutron tomography (down to 30 microns resolution) and the ability acquire radiographs for a field of view of 170x170 mm. The $\frac{L}{D}$ of the instrument (where D is the pinhole diameter and L is the pinhole-to-sample distance, this ratio is a limiting factor for spatial resolution) currently ranges from 650 to several tens of thousands although upgrades to achieve lower $\frac{L}{D}$ for higher temporal resolution tests are under way.

The second phase of the instrument, currently in progress, involves the development of a dedicated higher resolution setup (10 microns and below). The high neutron flux available automatically makes this a totally unique instrument, particularly since high resolution neutron imaging instruments are severely limited by flux. This phase will also see the installation of a polychromatic, divergent x-ray radiography setup aimed at bimodal tomography following the example of the Paul Scherrer Institut (PSI). This opens venues for several applications some of which are reviewed in the next section.

In agreement with the high resolutions sought, the setup is encased within a granite skeleton, to take advantage of the high thermal and vibrational stability of the material.

The setup is designed to be employed in a wide range of chemo-hydro-mechanical *in-situ* tests, and is capable of withstanding the weight of cells up to several hundreds of kilograms. Correspondingly, the instrument allows for voluminous cells thanks to the movable detector and the abundant free space above ($\sim$ 1 m) and below the instrument ($\sim$ 1.5 m).

This instrument is currently open for scientific proposals and its next proposal session is opening in July 2017 and closing on the 30^{th} of August 2017. Additional information can be found in the website of the project, https://next-grenoble.fr/.

†Institute of Engineering Univ. Grenoble Alpes
*e-mail: alessandro.tegattini@3sr-grenoble.fr

3. RESULTS AND ONGOING PROJECTS

This polyvalent instrument can help cast a new light on a variety of problems.

Laboratoire 3SR, the unit within UGA that co-pilots the project, does research into the mechanics of porous media and geomaterials (soil, rock and concrete). A key focus is therefore the hydro-chemo-mechanical tests of this broad class of materials.

In this context, notable example of the potential of neutrons and of the complementary of x-rays is the study of the permeability field in geomaterials and its inhomogeneous evolution with mechanical loading. This is pivotal for the development of new techniques for natural resource exploitation, *e.g.*, hydrocarbon and water production or CO_2 sequestration. The attenuation of hydrogen to neutrons can be exploited to follow a water front moving through dry geomaterials. Additionally, the isotope sensitivity of neutrons can be taken advantage of *e.g.* to follow alternate flushes of normal and heavy water while performing mechanical loading of porous materials. This method, pioneered in [1] has been adopted for explorations on multiple materials at NeXT, and some of the results obtained are presented here at ICTMS2017 [2, 3]. An important aspect of the water flow in porous media is the speed of the process, which requires tomographies down to one or two minutes (or even less) in order to follow this intrinsically three-dimensional process. Preliminary explorations at NeXT performed at this speed have shown promising results [3].

The complementarity of x-rays is highlighted in Fig. 1, where the silica-based microstructure, less visible to neutrons, is clearly apparent in x-rays.

Several other ongoing projects at NeXT employ analogous techniques to study problems ranging from the hydraulic fracturing of geomaterials (for example for hydrocarbon extraction or geothermal energy exploitation) to high temperature response of concrete. Other key properties of neutrons, such as their lower impact on living tissue (with respect to x-rays) are being exploited to study porous materials as bones or to explore the behavior of biofilms.

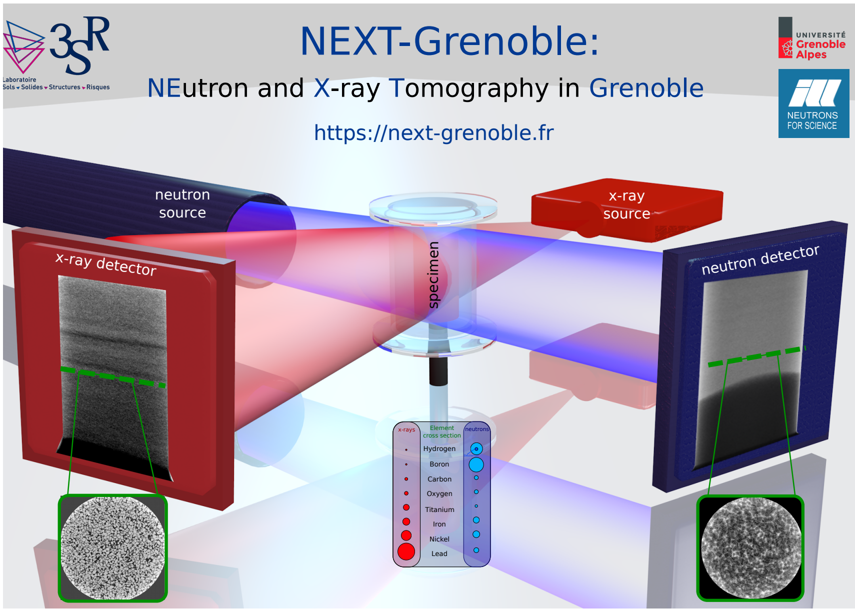

Figure 1: Sketch of the concept underlying NeXT: the high complementarity of x-rays and neutrons can be exploited, *for example* to study the hydro-mechanical properties of geomaterials. The flow properties can be explored using the hydrogen attenuation of neutrons while their evolving microstructure can be investigated optimally with x-rays.

References

[1] E. Tudisco & S.A. Hall. Full-field measurements of strain localisation in sandstone by neutron tomography and 3D-volumetric digital image correlation,*Physics Procedia-10th World Conference on Neutron Radiography*, 69, 509-515, 2015.

[2] M. Etxegarai & E. Tudisco & A. Tengattini & S. Hall & G. Viggiani, Hydromechanical Behaviour of Porous Rock Studied With Neutron Tomography,*Proceedings ICTMS2017*

[3] H Lewis & A Tengattini & G Couples & E Tudisco & EM Charalampidou & S Hall & K Edlmann & E Ando & M Etxegarai, Neutron radiography and tomography used to characterise water flow through a low permeability carbonate altered by experimentally induced fractures *Proceedings ICTMS2017*