	Experiment title: Direct observation of structural transitions in laser-shocked Bi by means of time resolved XAS	**Experiment number**: HC4011
Beamline: ID24	**Date of experiment**: from: 02/12/2018 to: 04/12/2018	**Date of report**:
Shifts:	**Local contact(s)**: R. Torchio, N. Sevelin	*Received at ESRF:*

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Report:

The aim of this experiment was to investigate Bi under dynamic solicitation using the laser shock technique coupled to x-ray absorption (XAS), a facility (HPLF-I) that has recenlty become available on beamline ID24. This project stands in the framework of a larger one involving XRD measurements under dynamic compression that we recently performed at beamline ID09 and whose results were recently submitted to PRL.

Despite it has been largely investigated, the Bi phase diagram still presents many open questions concerning for example phase boundary dependence on strain rate and hydrostaticity, phases metastability and nucleation, melting curve and liquid structure.

The target was a multilayer made of a sapphire window (200 microns thickness) glued on 10 microns thick foil of Bi from Goodfellow and a layer of polymide on the back side (125microns). The laser, delivering around 14 J at 1053 ns in square pulses of 8 ns, was focused down to 500 microns at the sample position. Single bunch (100ps) X-ray absorption measurements were performed at the Bi L3 edge (13.4 keV) using the XH detector during the 7/8+1 mode of the ESRF.

Two experimental session were performed. The first one was used to calibrate the laser induced pressure states in the targets by performing off line VISAR (Velocity Interferometer System for Any Reflector) measurements on reference samples. The second session was used to perform XAS measurement under laser induced compression.
The confined plasma-driven shock scheme provides a reproducible pressure time evolution in the Bi sample, allowing to maintain the shock states for several ns.

Our preliminary tests on a Bi foil showed that the sum of 10 single bunch acquisition could give a sufficient signal to noise ratio to discern the Bi L3 XANES features.

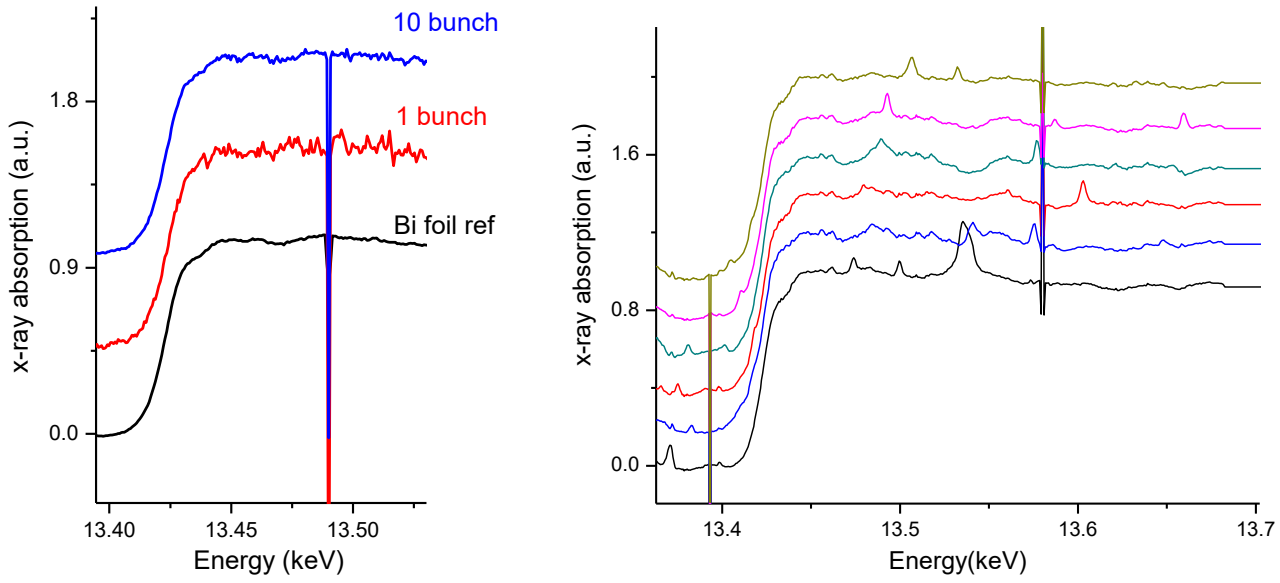

Figure 1: left: comparison of x-ray absorption spectra of Bi foil acquired over many bunches (black line), 1 bunch (red line) and 10 bunches (blue line). Right: XAS spectra of our Bi target showing diffraction peaks pollution from the sapphire window.

Unfortunately X-ray absorption spectra of the targets were polluted with bragg diffractions from the Sapphire windows (see Fig.1 right panel). Due to the complex setup, it was not possible to rotate the target to move the glitches out of the region of interest. This problem could be overcome, for future experiments, by using nanocrystalline or amorphous windows.

To avoid any possible misinterpretation, all shock data whose cold reference spectrum showed glitches in our region of interest (3.406-3.452 keV) were not taken into account, with the assumption that the Bragg lines should not move a lot under the induced conditions. In fact, the glitches are almost not visible in the single bunch spectra acquired under shock, but they may affect the global shape.

Following our results on ID09, we decided to investigate the Bi structural changes at 8, 12, 16 and 25 ns of laser-xrays relative delay. According to hydrodynamic simulation and preliminary VISAR measurements, a full conversion into BiV was expected at 8ns and full recovery of BiI at 25 ns.
Our data acquired at 8 ns are compatible with the BiI-BiV transition. The XANES shape shows changes at 13.432 and 13.437 (see Fig. 2 left top panel), similarly as obtained in static compression (Fig. 2 right top panel, from Y.H Chen et al., Chin.Phys.B Vol.25,No.10 (2016) 108103). Starting from 13.45 keV the shocked spectrum shows a flat shape likely as a consequence of high temperature. A slight edge shift to low energy is observed in the static data that is not observed in our data, this could be due to temperature as well but needs to be further investigated. At 25 ns the shocked spectrum looks more like the ambient one, apart from a small feature at 13.44 keV, suggesting the recovery of Bi I structure.

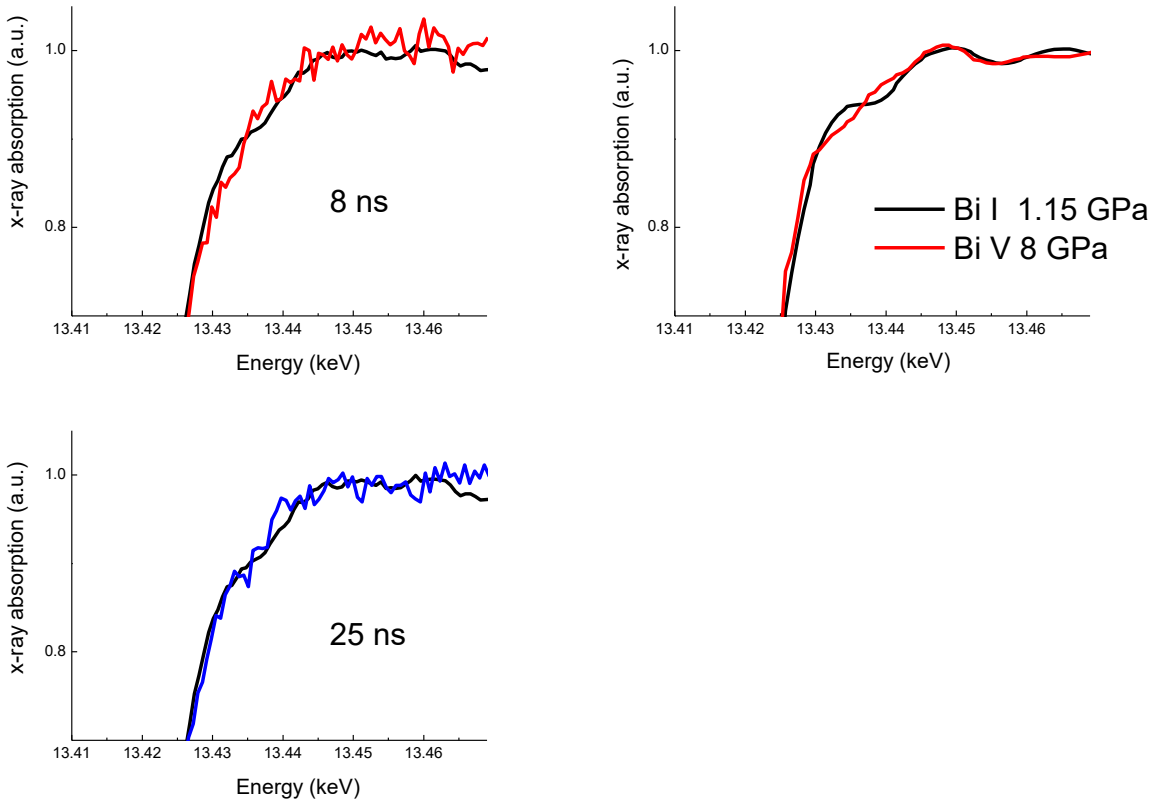

Figure 2: left: Avarage of 10 single bunch XANES spectra obtained under shock compression at 8ns (top, red line) and 25ns (bottom, blue line), compared to the ambient spectrum acquired over many bunches (black line). Right top panel: data from static compression after Chen et al. 2016.