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ABSTRACT:

Local Probes of Structure and Dynamics in Functional Materials: The ID14 Nuclear Resonance Beamline at ESRF

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Local probe techniques are essential for understanding the interplay between structure, dynamics, and functionality in complex materials. ID14 Nuclear Resonance Beamline at the European Synchrotron Radiation Facility (ESRF) provides a powerful platform for such investigations through a suite of synchrotron-based Mössbauer methods, including Synchrotron Mössbauer Spectroscopy (SMS), Nuclear Forward Scattering (NFS), and Nuclear Inelastic Scattering (NIS) of several Mössbauer active isotopes.

The presentation will give an overview of the capabilities of ID14, with emphasis on its ability to probe hyperfine interactions and vibrational dynamics with high energy resolution under a broad range of experimental conditions, such as extreme pressure up to 300 GPa, high external magnetic field up to 7 T, and temperatures from 2 K to 4000 K. The access to these range of extreme conditions and the possibility to access nuclear transitions open new opportunities for the study of functional materials in operando and non-ambient environments.

The versatility of nuclear resonance techniques will be illustrated through selected case studies related to functional materials, such as BiFe1-xNixO3 perovskites. While Fe-based systems remain a benchmark, particular attention will be given to the extension toward high-energy isotopes such as 121Sb, broadening the range of accessible materials. A key example will focus on SbSI, a ferroelectric photovoltaic compound, where combined measurements across multiple beamlines under extreme conditions provide a comprehensive picture of coupled structural and dynamical phenomena. These results demonstrate the strength of local probe approaches at ID14 and underline the growing impact of Nuclear Resonance techniques for advancing the understanding of functional materials.