^{57}Fe-Mössbauer Spectroscopy Platform

The physics at the heart of biology

Mössbauer spectroscopy is a non-destructive technique for the study of iron atoms within molecules.

It can be used to determine the oxidation state of the metal and its chemical and structural environment. Although the technique is generally used to study condensed matter, the platform at IRIG is distinguished by its expertise in the field of life-sciences. This platform investigates the active sites of iron-containing proteins, which may be isolated (*in vitro* studies) or produced in cells (*in cellula* studies).

Among all the Mössbauer spectroscopy platforms worldwide, only around ten focus on biological systems; the platform at IRIG is the only one of its kind in France.

Expertises

- **Identify**
  all types of Fe ions and determine their relative proportions
- **Determine**
  the oxidation state of Fe ions and the nature of their environment (coordination sphere, nature of the ligands)
- **Reveal**
  variations in the environment of Fe ions (change following a reaction or comparisons of different systems)
- **Track**
  oxidation state changes during a catalytic reaction
- **Identify**
  a catalytic form
- **Identify**
  and characterise reaction intermediates
- **Precisely describe**
  the electronic structure of Fe ions (spin state, zero-field properties, magnetic couplings)

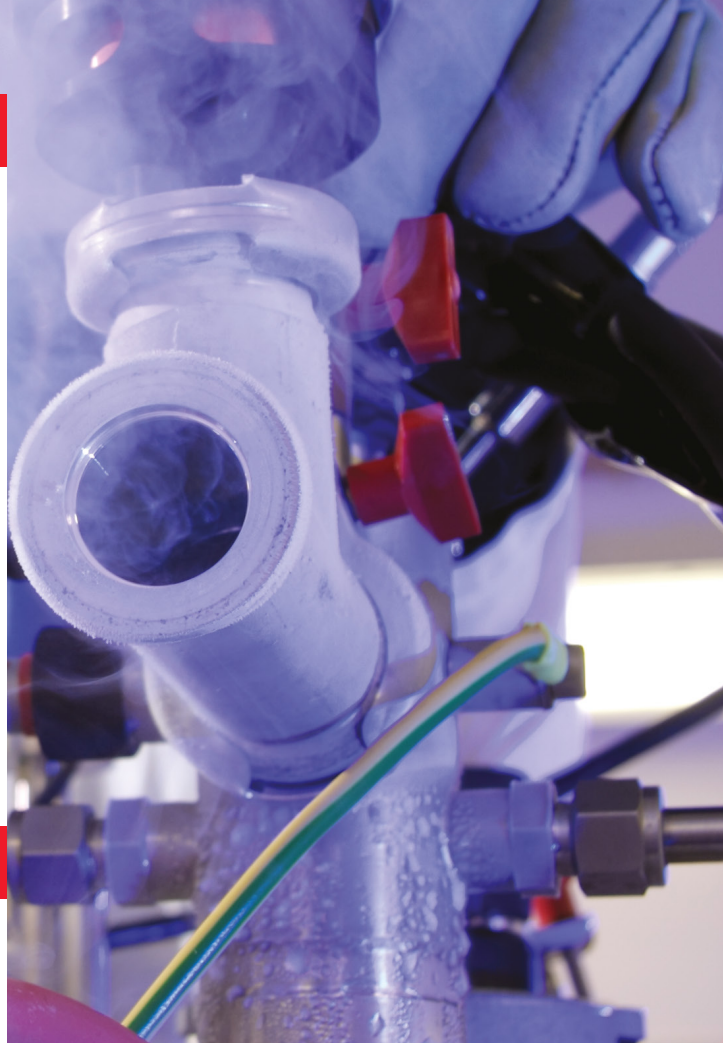
Focus

Kinetics

Rapid-Mix and Freeze-Quench

The capacity to measure the kinetics of a protein's transformation could be crucial in understanding how it works. The Rapid-Mix/Freeze-Quench method makes it possible to trap short-lived (25 ms or longer) reaction intermediates by instant freezing.

> These intermediates can then be studied individually by Mössbauer spectroscopy to determine the kinetic profile of state-change.



Technology and tools

- **Four Mössbauer spectrometers**
  Three equipped with a cryostat for work at very low temperatures (4 K) for improved sensitivity
  > Liquid-helium-free cryostat
  - Closed-circuit cooling not consuming cryo-fluids for temperatures ranging from 4 to 300 kelvins
  - Reliable and economically-viable technology for use during extended recording
  > Cryostat with superconducting magnet
  - Helium bath cryostat (2 - 300 K)
  - Cryomagnet which can produce an external magnetic field of up to 7 teslas
  - Measurements in low-field (60 mT) and high-field (>1 T) to target the electronic structure of iron-based cores
- **« Rapid-mix/freeze-quench » technique**
  to trap reaction intermediates
- **Simulation software**
  developed within the institute to deal with the specificities of molecular systems

Services

- **Multidisciplinary approach** combining physics, chemistry and biology
- **Expertise acquired over 10 years' studying** iron-containing proteins and their molecular models
- **Reactivity study** by « Rapid-Mix/Freeze-Quench » : characterisation of reaction intermediates and kinetic studies
- **Advice and assistance** to identify the most appropriate methodology of investigation
- **Services include** recordings, simulations and analysis of results

! NOT ONLY FOR PROTEINS

Although specialised in the study of proteins, the Mössbauer platform at IRIG is also well-equipped to study materials (spectra recordings and data analysis).

This spectroscopic method is particularly suited to the study of ferric/ferrous materials in the condensed matter domain.

Highlights

Angewandte Chemie International Edition
In cellulo Mössbauer and EPR studies bring new evidence to the long-standing debate on iron-sulfur cluster binding in human anamorsin

Angewandte Chemie International Edition
Dinitrogen coordination to a high-spin diiron(I/II) species

Journal of the american chemical society
Evidence for $[2Fe\text{-}2S]^{2+}$ and linear $[3Fe\text{-}4S]^{3+}$ clusters in a unique family of glycine/cysteine-rich Fe-S proteins form *Megavirinae* Giant viruses

2023 - conception : Irig communication unit - photos credits : CEA/IRIG

irig.cea.fr

Interdisciplinary Research Institute of Grenoble
CEA-Grenoble
17 avenue des Martyrs
38054 Grenoble cedex 9

TO DEVELOP YOUR PROJECT
https://www.cbm-lab.fr/Pages/PMB/Mossbauer.aspx

SCIENTIFIC DIRECTOR
Geneviève Blondin / +33 4 38 78 38 47 / genevieve.blondin@cea.fr

HEAD OF PLATFORM
Martin Clémancey / +33 4 38 78 02 06 / martin.clemancey@cea.fr