**PEPR Origins:** Origins, from planets to life - technological, societal and epistemic breakthroughs

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<https://www.cnrs.fr/fr/cnrsinfo/pepr-origins-entre-ruptures-technologiques-et-origines-de-la-vie>

(17 instruments, 28 partners )

MIRRPA projet is part of the axe 4: The emergence of life – Laboratory experiments and bioanalyses of early-Earth/Mars samples

**WP4.1 MIRRPLA: a Multiple-beam IRRadiation PLAtform to investigate the origin of organic matter**

**Labs:** CIMAP (Lead, A. Domaracka), PIIM (Partner, D. Danger)

***Scientific objectives*:** understanding the origin of primitive organic matter during the formation and evolution of the Solar System is fundamental since extraterrestrial organic matter delivery through asteroids and comets is one of the possible sources of organic matter available at the time of the early Earth. In astrophysical environments matter is constantly exposed to complex radiation fields (UV, X-rays, electrons and ions from solar winds, cosmic rays and ions trapped in magnetospheres). These different types of radiation act simultaneously, but existing laboratory astrophysics experiments are performed using single source irradiation and synergy effects are missed. Thus, there is the need to conduct simultaneous multiple-beam irradiation (photons, ions, electrons) of: (i) astrophysical ice analogs (containing small molecules like H2O, CO, CO2, NH3, CH3OH) or *ex-situ* solid samples to quantify formation of complex organic molecules/prebiotic species depending on the initial ice composition and temperature; (ii) complex organic matter (e.g. containing amino acids, nucleobases) to investigate their resistance under ionizing radiation and to simulate the space weathering of solar system bodies.

***Deliverable:*** A unique multiple-beam irradiation platform (UV photons, keV electrons and keV-GeV

ions) equipped with *in-situ* infrared spectrometer and mass spectrometers. This new polyvalent

instrument will be open to the whole scientific community (e.g. radiation biology, environmental and

materials science) as well as to industry via the GANIL-CIMAP-CIRIL user’s facility.

***Description:*** The uniqueness of the proposed set-up consists in the combination of different types of ionizing radiation (photons, electrons, ions) including the possibility of simultaneously irradiating icy samples (10-300K), e.g. GANIL ion beam with UV photons and/or electrons. The sample modification will be monitored *in-situ* by means of Fourier Transform Infrared Spectroscopy (FTIR) and sputtered/desorbed species by mass spectrometry. Moreover, temperature-programmed gas

chromatography mass spectrometry (GC-MS) will be installed in a dedicated separated chamber to

analyze synthesized complex molecules. The project partners already master all technologies needed

to develop this system, which have been demonstrated by several proofs of concepts within recent

experimental developments (e.g. ANR projects IGLIAS, RAHIIA\_SOMM and VAHIIA).

***Other applications and benefits:*** The unique worldwide multi-beam platform at the GANIL-CIMAPCIRIL

user’s facility will be open to the whole scientific community. We foresee applications in:

*Health*: combined mixed beams (e.g. photons and ions) are proposed be used for radiotherapy

resistant tumors. MIRRPLA will give a unique opportunity to investigate fundamental processes by

mixed irradiation of biomolecules and DNA fragments to develop new cancer treatment protocols.

*Environmental sciences*: polycyclic aromatic hydrocarbons (PAHs) are produced in incomplete

combustion and they are key intermediates in the inception and growth of soot particles. Moreover,

carbonaceous nanoparticles can be covered with water ice in the upper part of the atmosphere and be exposed to different kinds of ionizing radiation. MIRRPLA will allow investigating the reactivity of

soot analogues covered with water ice triggered by ion/photon/electron irradiation.

*Material sciences:* this unique facility allows investigation of (i) material aging in mixed irradiation

environments (nuclear fuel cells, reactor materials, ceramics/glasses for storage of radioactive waste

- see letter from CEA in Annex; polymers); (ii) simultaneous multi-radiation effects on materials used

in spacecraft and space missions (hull, electronics).