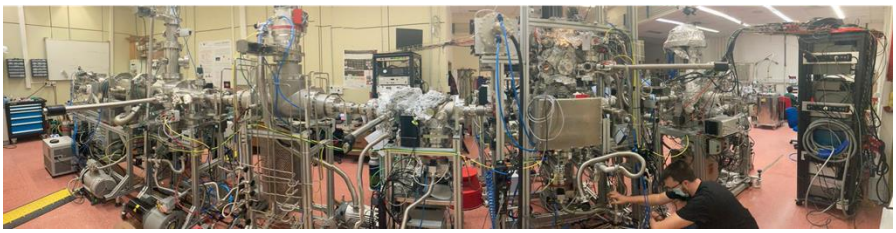
Inventory of experimental and theoretical resources available for NanoSpace COST Action	
Country:	SPAIN
Name of Institution/Laboratory:	INSTITUTE OF MATERIALS SCIENCE OF MADRID, CSIC / STARDUST
Contact information (name, e-mail):	José Ángel Martín-Gago (gago@icmm.csic.es) Gonzalo Santoro (gonzalo.santoro@csic.es)
Website:	https://wp.icmm.csic.es/esisna/
Short description **(max 0.5 page)** of available techniques (experiment or theory): If appropriate, please include 1 picture/figure and caption highlighting resources.	STARDUST is an experimental infrastructure dedicated to the production and in-situ analysis of cosmic dust analogs in the Circumstellar Envelopes (CSEs) of Asymptotic Giant Branch (AGB) stars and on the physico-chemical evolution of cosmic dust towards the interstellar medium (ISM) and in Dense Molecular Clouds (DMCs). Importantly, all the process from analog production through processing and characterization is performed in-situ in UHV conditions, which ensures both a high control on the experimental conditions and the absence of spurious effects related to air exposure of the analogs. Briefly, the production of nanometer-sized dust analogs is carried out by means of a sputtering gas aggregation source. This is the only infrastructure around the world using this approximation for cosmic dust analog production. Its particularity lies in that the analogs are produced starting from atomic precursors and the chemistry of analog formation is driven by neutral-neutral reactions, closely resembling the processes taking place in the CSEs of AGBs. After production, the analogs can be heated up (to 1500 K), ionized and accelerated in the gas phase. Afterwards, the analogs can be characterized by a battery of techniques, namely, IR spectroscopies (transmission and IRRAS), electron spectroscopies (XPS, UPS, AES..) and thermal desorption mass spectroscopy (mass range 0-512 amu; T= 300-1000 K), by depositing them on a substrate. Once deposited, the nanograin analogs can be energetically processed by UV photons (10.2 eV or 21 eV), low energy electrons (0-500 eV), ions (0-6 keV) and/or exposed to atomic H and O, mimicking the processes occurring in the ISM. Finally, the dust analogs can be coated by or embedded in molecular ices at low temperatures (15 K) and energetically processed to study the dust-mediated chemical processes in DMCs. Thus, STARDUST can simulate in the laboratory the complete journey of cosmic dust from its formation in the CSEs of AGBs to DMCs, where dust is coated by molecular ices and subjected to energetic processing. These capabilities are unique worldwide.

	   Figure 1. Upper row: schematics of the processes simulated by the STARDUST experimental facility, from the production of nano-sized dust grains in AGB stars to the processing in the ISM and DMCs. Lower row: Picture of STARDUST, an 8 m long UHV experimental facility.
Sample/target description (e.g. gas, clusters, solid,…):	Nanoparticles and molecular ices.
How to access to experimental/computational resources (e.g. through collaboration, user facility proposal calls,….):	Access can be granted through collaboration. In addition, transnational access to the STARDUST experimental station is currently offered through the European project Nanoscience Foundries and Fine Analysis Europe | Pilot (https://www.nffa.eu/) for nanoscience related projects.
References **(max 5)**:	- L. Martínez, G. Santoro, P. Merino, et al., "*Prevalence of non-aromatic carbonaceous molecules in the inner regions of circumstellar envelopes*", Nature Astronomy. 4, 97-105 (2020). - G. Santoro, L. Martínez, K. Lauwaet, et al. "*The chemistry of cosmic dust analogues from C, C_2 and C_2H_2 in C-rich circumstellar envelopes*", ApJ. 895, 97 (2020). - L. Martínez, P. Merino, G. Santoro, et al. "*Metal-catalyst-free gas-phase synthesis of long-chain hydrocarbons*", Nat. Comm. 12, 5937 (2021). - M. Accolla, G. Santoro, P. Merino et al. "*Silicon and hydrogen chemistry under laboratory conditions mimicking the atmosphere of evolved stars*", ApJ. 906, 44 (2021). - G. Santoro, J. M. Sobrado, G. Tajuelo-Castilla, et al. "*INFRA-ICE: an ultra-high vacuum experimental station for laboratory astrochemistry*", Rev. Sci. Instrum. 91, 124101 (2020).