**Description of the infrastructure**

Name of the infrastructure (and its installations, if applicable): **LNL-LNS**

Location (town, country) of the infrastructure: “Laboratori Nazionali di Legnaro” (LNL, at Legnaro, Padua) and “Laboratori Nazionali del Sud” (LNS at Catania) are both property of Istituto Nazionale di Fisica Nucleare (INFN) and are devoted to Fundamental and Applied Nuclear Physics.

The research activities in the two laboratories are strictly coordinated and complementary, due to the large variety of beams and experimental set-ups offered to the users.

Web site address: www.lnl.infn.it www.lns.infn.it

Annual operating costs (excl. investment costs) of the infrastructure (€): 10.000.000

Description of the infrastructure:

**Accelerator Facilities**

The LNL and LNS laboratories have different accelerator complexes providing light and heavy ion beams up to 80 MeV/u. In particular, the accelerators in use are:

* the PIAVE/ALPI accelerator complex at LNL, equipped with a ECR source and the superconducting RFQ injector PIAVE, which delivers ion beams with A>90 up to approximately 15 MeV/u;
* the Tandem/ALPI accelerator complex at LNL, composed of the 16 MV XTU-Tandem accelerator (for beams with A<90) coupled to the ALPI superconducting Linac, delivering heavy-ion beams with energies up to 10 MeV/u.
* the Superconducting Cyclotron at LNS providing a wide variety of heavy-ion beams with energies up to 80 MeV/u.
* the 15 MV SMP Tandem accelerator at LNS providing heavy-ion beams with energies of a few Mev/u.

The LNS Superconducting Cyclotron will be equipped with a second beam extraction system that will also provide higher intensity stable beams. Consequently, the previous FRIBs (in Flight Radioactive Ion Beams) facility will be upgraded to a new FRAgment Ion Separator (FRAISE) for exotic beams produced via projectile fragmentation.

During the period of the offered Transnational Access the SPES facility for the production of radioactive beams will come into operation. SPES is an ISOL type facility based on the fission of a UCx target induced by a primary proton beam delivered by the high intensity cyclotron B70 (70 MeV energy, 700 A current).

The facilities devoted to applied, interdisciplinary and biomedical physics are based on:

* The Van de Graaff accelerators 2.5 MV AN2000 and 7 MV CN at LNL delivering light-ion beams.
* The CATANA facility at LNS where, besides the proton-therapy, biomedical physics experiments using proton and carbon beams from the cyclotron are performed.
* Thanks to the presence of two exit ports, the SPES cyclotron can also be used for research and development activities on the production of innovative radioisotopes for medicine and neutrons for applied physics.

**Research instrumentation**

LNL and LNS have several state-of-the-art detection systems installed at dedicated beam lines. Among them we can mention:

* the GALILEO gamma spectrometer for advanced in-beam γ-ray spectroscopy studies at LNL, a high-resolution Ge array implemented with various complementary detectors such as light particles and heavy fragments detectors, a dedicated plunger device for lifetime measurements, etc.
* The heavy-ion magnetic spectrometers PRISMA at LNL and MAGNEX at LNS for the study of quasi-elastic processes and single and double charge exchange reactions
* The charged particle array detectors GARFIELD+RCo at LNL and CHIMERA at LNS for the study of the dynamics and thermodynamics of nuclear reactions
* The PISOLO set-up at LNL, based on a beam deflector followed by a time-of-flight spectrometer, for the study of sub-barrier fusion reactions.
* The BELINA facility, installed at the CN accelerator of LNL, which is devoted to the production of (pulsed) neutron beams through the 7Li (p,n) reaction for both astrophysics and applied research studies.
* The STARTRACK detector for micro dosimetry studies, the micro-beam line at the AN2000 accelerator for elemental analysis of samples of different nature are among the facilities for applied and interdisciplinary physics at LNL.
* the LANDIS laboratory at LNS for non-destructive in situ analysis of archaeological samples.
* A beta-decay station and a mini-orange spectrometer for nuclear structure studies using non-reaccelerated SPES beams are in the early installation phase at LNL.

It is also worthwhile to mention that the European gamma spectrometer AGATA will be moved to LNL in July 2021 to be coupled to the large acceptance magnetic spectrometer PRISMA. The experimental campaign with stable beams will start in spring 2022.

The international relevance and global quality of the research performed at LNL and LNS, are testified by the large number of papers in Scientific Journals with high impact factor (about 350 per year) and the number of users from foreign institutions (about 500 researchers per year).

The previous experience on Transnational Access (ENSAR, ENSAR2), confirmed the widespread interest of EU, as well as worldwide groups to the LNL-LNS research infrastructures.

The expertise of LNL-LNS finds application in several fields such as the hadrotherapy (CATANA facility), the safeguard of Cultural Heritage masterpieces (LANDIS laboratory – patent n. 9807435 and n. 2885370), the development of advanced composite materials (patent n. EP 0826434 (A1), and patent n. RM2007A000522), Microchannel technology, applied to heat dissipation systems (patent MI2014A000805), production of high quality radionuclides as radiopharmaceuticals precursors from isobaric separation in ISOL targets (patent MI2014A000145), new detector for ionizing particle in SiC (INFN patent deposited nr. 102018000007139), the development of new techniques for the fabrication of resonant cavities.

Services currently offered by the infrastructure:

Outside users receive support by the local research teams and have access to well-equipped laboratories and services with high-level expertise. The main services offered to users are the following:

* A Detector Laboratory at LNL, one the most advanced laboratories in Europe for testing and repairing High-Purity Germanium (HPGe) detectors.
* Target laboratories at LNL and LNS for the production of targets and thin films depositions for nuclear physics experiments and interdisciplinary projects, respectively.
* Technical assistance for the installation of new set-ups in the experimental areas of LNL and LNS, the maintenance of vacuum instrumentation, pumping systems, electrical components and mechanical parts of the existing apparatuses.
* Computer centres and Data Acquisition Services.
* Cellular and molecular biology laboratories at LNS.
* A surface technology and superconductivity laboratory at LNL.
* Guest houses for the users.

**Description of work**

Modality of access under this proposal:

All the above-mentioned facilities (accelerators and/or experimental set-ups) are open for access. This must be asked by submitting a written proposal plus an application form from users interested in the EC support. Contacts with the heads of Accelerator and Research divisions must be established in advance to obtain information about the characteristics and the use of the facility and to comply with the scientific scheduling and safety rules. Local research groups are in charge of the experimental facilities, many of which were built in international collaborations. We estimate to fund 50 projects during the 4 years of the present proposal. We expect to support an average of 4/5 peoples per project for an average stay of 7 days per user (including preparation work, data taking and preliminary data analysis). The users will be supported with a per diem and the refund of travel expenses.

Support offered under this proposal:

The services offered include: 1) engineering project service, mechanical machine shops, vacuum and electrical maintenance; 2) vacuum laboratories; 3) cryogenics and superconductivity laboratory; 5) Laboratories for target production; 4) laboratory for sputtering and composite materials; 5) laboratory for treatment of materials; 6) Nuclear Analytical Laboratory and 7) micro and nano dosimetry Test laboratory. Logistics support includes: 1) General store for goods and components; 2) Canteen and cafeteria service at LNL; 3) Guesthouse; 4) Library and documentation service.

Outreach of new users:

Calls for proposal at LNL and LNS are advertised on the web pages (www.lnl.infn.it, www.lns.infn.it) and distributed through an e-mail list including PhD students and post-doctoral fellows. In addition, the minutes of the meeting of the Laboratory user groups (every 6-12 months) are distributed to inform the community on practical questions such as the time schedules related to work (maintenance, upgrade or new implementation) at the specific installation. Also, surveys are made when decisions have to be taken involving beam time scheduling or new beam development.

Review procedure under this proposal:

Scientific proposals requiring access to research infrastructures of both laboratories undergo a peer review selection based on the scientific merit. The proposal evaluation is carried out by the international scientific program committees (PAC) appointed by INFN.

As in the past Transnational access programs, the Projects will be selected by a User Selection Panel for Transnational Access appointed by the LNL and LNS Directors. The proposals will be screened on the basis of their scientific merit starting from the local PACs evaluation. The support will be granted with priority to new users, users coming from countries where similar Infrastructures do not exist, young scientists and women. Communication of the selection results, whether positive or negative, will be sent to all spokespersons.