The LARAMED Facility Status

J. Esposito[1], P. Antonini[1], M. Calderolla[1], S. Cisternino[1], A. Duatti[1,2], P. Favaron[1], G. Fiorentini[2], G. Keppel[1]
P. Martini[1,2], M. Maggiore[1], L. Mou[1], M. Pasquali[1,2], L. Pranovi[1], G. Pupillo[1], C. Rossi Alvarez[1]
L. Sarchiapone[1], G. Sciacca[1], H. Skliarova[1]

[1] *INFN, Laboratori Nazionali di Legnaro, Legnaro (Padova), Italy*
[2] *INFN, Sezione di Ferrara, Ferrara, Italy*

INTRODUCTION

LARAMED (LAboratory of RAdioisotopes for MEDicine) is the new infrastructure, now under construction at Legnaro National labs (LNL), aimed at becoming an international-class level and well-established research center for developing innovative applications of nuclear physics to medicine [1]. Although originally spawned from SPES project (the so-called SPES-γ stage), has now achieved an independent status as a stand-alone research line for the Italian National Institute of Nuclear Physics (INFN). The goal of LARAMED project is to have at LNL an internationally recognized center for research and development of unprecedented medical radionuclides, still unavailable for the scientific and clinical community, which could play a key role in patients' treatment and clinical research purposes. LARAMED main goals will cover different topics, ranging from basic nuclear physics (excitation function experimental measurements), to engineering aspects (high power production targets) and radiochemistry issues (improvements of separation purification techniques). Albeit the research facility is yet to become fully operative, LARAMED team has already started working on the different research lines focused on the cyclotron production of conventional medical radionuclides, such as Tc-99m, as well as the emerging ones showing a high potential interest in nuclear medicine, such as Mn-52 ($t_{1/2}$=5.591 d, $<E_{\beta+}>$=242 keV (29.4%)), Cu-67 ($t_{1/2}$=61.83 h, $<E_{\beta-}>$=141 keV (100.0%), $<E_{\gamma}>$= 185 keV (48.7 %)), Cu-64 ($t_{1/2}$=12.701 h, $<E_{\beta+}>$= 278 keV (17.60 %), $<E_{\beta-}>$= 190 keV (38.50 %)), Sc-47 ($t_{1/2}$=3.35 h, $<E_{\beta-}>$=162 keV (100.0%), $<E_{\gamma}>$= 159.38 keV (68.3 %)) [2]. A short overview of the LARAMED facility status is here reported.

THE LARAMED FACILITY STATUS

The driver for both SPES and LARAMED facilities is the powerful model 70p cyclotron, manufactured by BEST™ Theratronics (Canada) and already installed in the central bunker located at the underground floor of the SPES/LARAMED building, which layout is shown in Figure 1. The cyclotron, already commissioned in 2016-2017, is able to deliver two beams of accelerated protons at the same time, with tunable energy in the range 35-70 MeV and total current up to 750 μA, due to a double extraction system. There are very few cyclotrons around

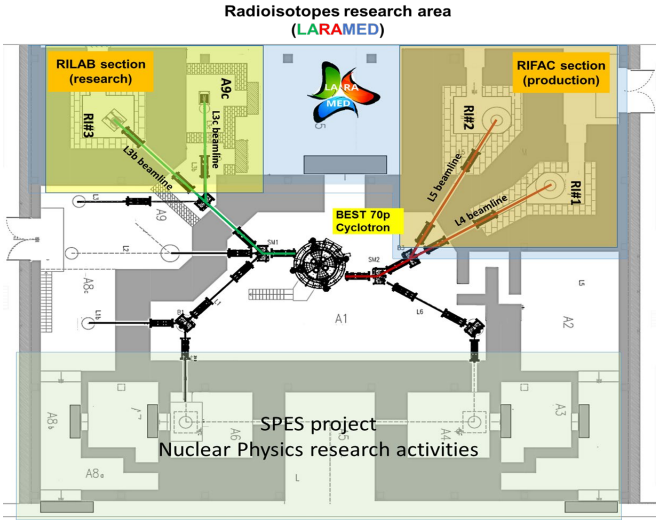

Figure 1: Layout of the SPES/LARAMED building underground level, showing the cyclotron room with the final beamlines configuration. In the upper stage the LARAMED area dedicated to radioisotope research/production activities is highlighted with the RILAB and RIFAC irradiation bunkers.

the world having similar performances for the time being: the ARRONAX facility in France, mainly devoted to routine radioisotope supply, with a limited time to research activities, while another one located in the United States (ZEVACOR), but planned to be a production site only. Both of them based upon the IBA C70 cyclotron. Each extraction beamline is further split by two main switching magnets in additional sub-lines, which will be driven towards other irradiation bunkers dedicated to different research purposes (Figure 1). In particular, two of them, will be used for LARAMED experimental research activities at the so-called RILAB (RadIoisotopes LABoratory) section at underground level (Figure 1). One dedicated to irradiation of high power solid targets, the other one for xs measurements by using very low beam currents. At the opposite side the RIFAC (RadioIsotopes FACtory) facility, where two additional beamlines will be used for the production of massive amounts of radioisotopes to be distributed to hospitals and clinical departments for both routine and clinical research purposes. This latter activity is planned to be pursued in collaboration with a private partnership for market-driven purposes. The main features (beam energy and current) planned for each of the four proton beamlines aimed at the

radioisotopes research and production activities at the LARAMED facility, are summarized in Table 1.

Table 1. Proton-beam specification for the LARAMED beamlines and related bunkers for Radioisotope production (RI) and Research and Development (R&D) planned activities.

	RIFAC		RILAB	
Purpose	**RI production**		**RI R&D**	
Target station/Bunkers	RI#1	RI#2	RI#3	A9c
Expected Current	500 μA	500 μA	300 μA	≤ 1 μA

The beamline towards the RI#3 bunker has been already purchased and all components and ancillaries are available at LNL since late August 2018. However, the whole beamline will be installed the next year, once the last bunker dedicated to nuclear physics measurements, A9(b+c), will be finally built and all technical supply services available inside. The xs bunker infrastructure is planned to be completed on the late summer 2019. The second beam line is instead foreseen to be purchased at the end of 2019 and installed in the second half of 2020. Moreover both target stations and target transfer systems are scheduled to be installed in the end of 2020. In Figure 2 a layout sketch of the LARAMED laboratories foreseen at the upper floor above the cyclotron vault is shown. This area comprises the RILAB radiochemistry labs (construction in progress), designed following the most advanced technological approaches in compliance with ISO international regulation. It will be dedicated for handling the yielded radioisotopes, following the necessary purification and quality control stages. The RILAB-target lab, under preliminary design stage, will be instead devoted to advanced R&D activities for innovative targets manufacturing, aimed at nuclear physics and medical radioisotopes production. In particular, a major research objective will be the study of new types of high- power

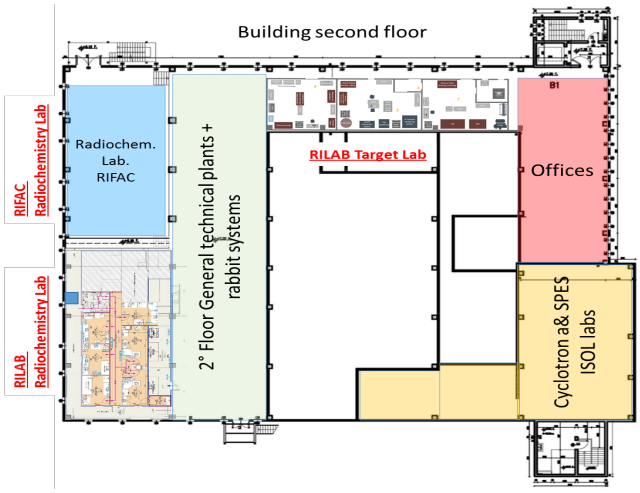

Figure 2: LARAMED radiochemistry and target manufacturing labs located at the second floor of SPES/LARAMED.

Figure 3: Some pictures showing the advancement steps of the new LARAMED RILAB radiochemistry lab (the so-called-

compound): (top) the first hot cell installed; (bottom left) the central laboratory lane; (bottom-right) one of the passbox between different lab areas.

solid targets, capable to exploit the full performance of the BEST cyclotron. In a near future the RIFAC labs will be realized as well, for radioisotope /radiopharmaceutical production, shared with the private partner. Some images which give evidence of the advancement in the construction status of the RILAB radiochemistry lab are at last displayed in Figure 3. The upper picture shows the first hot cell which has been already installed. In the final laboratory layout, a total of 7 hot cells are indeed foreseen, which arrangement is planned as follows: n. 2 for irradiated targets processing (target area); n. 2 for radioisotope manipulation and related radiochemistry (radiochemistry area); n. 2 for the radiopharmaceutical preparation in the clean room (not available in the starting stages); n .1 dedicated to recovery and chemical reprocessing of isotopically enriched material (target recovery area). The completion of the RILAB compound ready to be used, with the HVAC system (Heating, Ventilation and Air Conditioning) on, as well as electrical, gas, water supplies and the necessary radiological and environmental protection system operational, is planned on 2020. Despite the still incomplete implementation of the irradiation and laboratory facilities, a number of research projects are underway within the framework of the LARAMED program (see other contributions submitted to AnnRep).

REFERENCES

[1] J. Esposito et al., Molecules 2019, 24, 20; doi:10.3390/molecules24010020

[2] National Nuclear Data Center (NNDC) Database 2.7. http://www.nndc.bnl.gov/nudat2/