The quest of proton emitting nuclei wiht the S^3-LEB apparatus

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The Super Separator Spectrometer S^3, coupled to the new superconducting linear accelerator SPIRAL2-LINAC, has been developed to create new opportunities for studies of heavy and super-heavy nuclei, as well as in the vicinity of the N=Z region and at the proton dripline. The nuclei of interest will be produced at the entrance of S^3, using fusion-evaporation reactions, and will be separated from the intense background contamination while flying through the spectrometer. The S^3-LEB (Low Energy Branch) [1,2] apparatus will sit at the focal plane of S^3 and will neutralize the radioactive isotopes in a gas cell. Ground and isomeric state properties of nuclei of interest will then be studied at S^3-LEB using high-resolution laser spectroscopy, decay spectroscopy and mass spectrometry.

The reaction products from S^3 will be thermalized and neutralized in the gas cell, filled with argon, and extracted as a gas jet, formed by a convergent-divergent (de-Laval) nozzle, where laser ionization spectroscopy will take place. The gas jet offers a suitable environment for high-precision laser ionization spectroscopy due to reduced Doppler and pressure broadening effects, and will provide a spectral resolution better than 300 MHz [3], while maintaining a high efficiency. This technique will enable access to nuclear spin, electromagnetic moments and nuclear charge radii measurements. Laser-ionized ions will then be guided by a series of radiofrequency quadrupoles to the PILGRIM multi-reflection time-of-flight mass spectrometer, for beam purification and/or mass measurements, or to the decay spectroscopy station, SEASON.

The S^3-LEB apparatus is fully assembled and currently under commissioning at LPC Caen. Recent results from the commissioning will be presented, including the first in-gas-jet high-resolution laser spectroscopy results for stable erbium. The new S^3 facility will produce neutron-deficient nuclei with unprecedented yields including proton emitting nuclei. We propose here to use the in-gas-jet laser ionization and spectroscopy techniques, as well as decay spectroscopy and mass spectrometry techniques, to determine the ground-state properties of proton emitting nuclei with an unprecedented precision.

[1] J. Romans *et al.*, Atoms **10** (2022) 21
[2] J. Romans *et al.*, NIM B **536** (2023) 72
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