Doctoral INPhINIT - INCOMING Fellowship Programme 2019 Call for applications

Position: A laser-generator of ^{11}C for PET medical imaging pre-clinical studies

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Centre description

The Galician Institute for High Energy Physics (Instituto Galego de Física de Altas Enerxías, IGFAE) is a joint research institute of the University of Santiago de Compostela and Xunta de Galicia (the Galician Autonomous Government). It was officially created on July 2, 1999. The main goal of the Institute is to coordinate and foster the scientific and technical research in the field of High Energy Physics, Particle and Nuclear Physics and related areas as Astrophysics, Medical Physics and Instrumentation. Of primary importance is the planning and promotion of the relation with large experimental facilities, especially with CERN, GSI/FAIR and the Pierre Auger Observatory at present.

The experimental groups at IGFAE coordinate the Spanish participation in the LHCb Collaboration at CERN, the Spanish participation in the Pierre Auger Observatory, as well as the Spanish participation in the GSI/FAIR nuclear facility. Members of the Institute have a relevant participation in the LHCb upgrade planning, in the LHeC project development and planning, etc. In the last couple of years, a new line has also been open with the building of a new facility (LaserPET) at the University of Santiago de Compostela aiming to produce radioisotopes for medical use by a laser-induced plasma accelerator. Moreover, the theory section of the Institute holds an excellent international reputation, with participation in different international committees, invitations to plenary talks and large-impact publications.

Research project and research line description

Positron-emission tomography is one of the most powerful technologies for medical imaging. PET radiotracers generation strategy is based in massive production centres and distribution, limiting the use to relatively long-lived radiotracers as 18F. Decentralized production of radiotracers may open new possibilities, in particular for the use of PET molecular imaging in diseases diagnostics or drug discovery based on short-lived positron-emitters i.e. 11C. Laser-plasma acceleration could be the enabling technology to produce on-demand doses of PET probes at low cost, in automated user-friendly device. The compact size of laser-plasma accelerators would reduce the cost of the accelerator and required infrastructures, in particular radiation shielding. Further cost reduction would be brought by kit-based radiochemistry systems presently under development.

At present, laser-plasma acceleration has been proven and understood up to a large extent. The production of medical radioisotopes by this method has been even demonstrated, albeit not in clinically useful quantities. Several technological challenges should be solved. Most of the experiments performed so far are based on the so-called single shot approach. The multi-shot or continuous operation should be considered as the next priority.

The Experimental Group of Nuclei and Particles (GENP www.usc.es/genp) at IGFAE has a recognized trajectory in the field of fundamental and applied Nuclear Physics with highly skilled scientists an outstanding international impact. In particular, GENP scientists promoted the construction of the Laser Laboratory for Acceleration and Applications (L2A2 www.usc.es/L2A2) at the USC. This is a new research infrastructure in the field of laser-plasma acceleration and its applications. One of the main pillars of the scientific program of L2A2 is the LaserPET project aiming at demonstrating the competitiveness of laser-sources for the production of short-lived PET radioisotopes.

Job description

The aim of the proposed position is to contribute to the development of the technology required for the continuous mode operation of a laser-generator of 11C for pre-clinical PET medical imaging studies. Apart from the increase in the pulse repetition rate of the laser systems, optimizations in the laser focusing, and the use of advanced target materials could drastically increase the final production of medical radioisotopes with a laser generator. Another option will be the use of nuclear reactions better suited for the Maxwellian-like energy spectra of the ions accelerated by laser. As an example, carbon-11 can also be produced in the reaction 10B(d,n)11C.

The candidate should contribute to some of the following tasks:

- **Identification of optimum reactions** for laser-induced radioisotope production. Some key medical radioisotopes whose production by laser accelerators could be competitive with respect to standard production techniques will be identified and the expected production estimated.
- **Technical developments** for the continuum operation of a laser radioisotope generator. The main developments will concern the technologies required for an advanced laser-generated ion source:
  - Multi-shot laser-plasma target assemblies based on liquid films or rotating wheels.
  - New sensors for laser-accelerated ion position and intensity diagnosis.
  - Transport systems for laser-accelerated ions.
- **Feasibility studies**. The production of 11C will be demonstrated at the L2A2 laser facility at USC. Then the conditions for the final production of pre-clinical or clinical doses will be investigated.