Two-years postdoctoral fellowship at LPSC (Grenoble, France)

Development of a novel technique for TOF-based proton imaging

Project description

A very high ballistic precision and optimal tumour coverage may be in principle achieved with proton therapy, but uncertainties in patient tissue composition, physiological movements or transient modification of the anatomy may lead to significant errors in treatment delivery.

In order to fully exploit the potential of this technique, we are currently developing a novel system for real-time control of particle therapy, based on TOF-resolved (Time-Of-Flight) Prompt Gamma (PG) imaging with 100 ps time resolution, namely TIARA (Tof Imaging ARrAy). The system will consist of a set of small size, ultra-fast pixel detectors (~1cm^3) fixed on a rigid support surrounding the irradiated volume to achieve 3D coverage. [1,2,3]. TIARA will be read in time coincidence with a fast beam monitor. The TOF between the beam monitor and the TIARA pixels, together with TIARA pixels' positions constrain the PG vertex coordinates allowing a 3D reconstruction of the ion range in real-time and with a millimetric precision at pencil beam level [2]. The dedicated reconstruction algorithm developed paves the way to a new medical imaging technique, Prompt Gamma Time Imaging (PGTI) that can be used for both proton range monitoring and proton radiography. While the feasibility of the first application has already been proven by our collaboration [3], the latter is still to be investigated. Through MC simulation and dedicated experiments at protontherapy facilities, our aim is now to establish the potential and the limits of TOF-based proton imaging with the TIARA detector. This multidisciplinary project has recently been funded by the European Community (ERC grant PGTI) for a duration of five years. Physicists, engineers, mathematicians and clinical medical physicists from three French institutes (two CNRS labs, LPSC[1] and CPPM[2] and the CAL[3] proton therapy centre) are jointly working on the development and test of the TIARA detector and the PGTI reconstruction algorithm in order to reach their clinical applicability.

Job description

The current position is based in Grenoble, at the CNRS Laboratory of Subatomic Physics and Cosmology (LPSC). We are looking for a highly motivated candidate to investigate the use of PGTI reconstruction for TOF based proton imaging. The candidate will conceive and implement dedicated Monte Carlo simulations to study the image quality (spatial resolution, SNR…) achievable with this technique and the dose delivered to the patient in different scenarios. Starting from simplified geometries the study will progressively include all parameters that will have an impact on the experimental application, including the simulation of realistic patient anatomies based on digital phantoms and patient's CT images. Following the simulation results, the successful candidate will propose practical experiments that can be reproduced at a protontherapy facility to validate the feasibility of the technique.

This position mainly involves MC simulation, image reconstruction and data analysis tasks but, depending on the candidate profile and interests, she/he may directly participate to the experimental campaigns at CAL.

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[1] Laboratoire de Physique Subatomique et Cosmologie, Grenoble, France (https://lpsc.in2p3.fr/).

[2] Centre de Physique des Particules de Marseille, Marseille, France (https://cppm.in2p3.fr/).

[3] Centre Antoine Lacassagne, Nice, France (https://www.centreantoinelacassagne.org/).

The selected candidate will collaborate with mathematicians and physicists at CPPM who developed the original reconstruction algorithm and with engineers, researchers and medical physicists at LPSC and CAL who are involved in the TIARA detector development and test.

Activities

- Design and implement MC simulations to study the feasibility of TOF based proton imaging;
- Participate to the conception of experiments at proton beam facilities;
- Upload, document and maintain the software developed on GitLab;
- Format research data output according to the project Data Management Plan;
- Interact and coordinate her/his work with other members of the collaboration;
- Present her/his work to collaboration meetings and conferences;
- Write scientific papers, technical notes and reports.

Candidate profile

- PhD in physics/medical physics or equivalent;
- Advanced knowledge of radiation detection physics and nuclear physics;
- Extended and proven experience in Monte-Carlo simulation (Geant4, GATE…);
- Extended experience with python and its most common scientific libraries;
- Previous experience in medical imaging research is highly desirable;
- Previous experience with detector instrumentation is welcome;
- Ability to present and synthesize research results;
- Good written and oral English skills;
- Ability to work in a collaborative environment.

Start date: as soon as possible.
Term of contract: 24 months with 3 months probationary period.
Contract: full-time.
Salary: starting from 2648 euros per month (gross salary) according to experience and in agreement with French public function salary grids.
Experience: all levels will be considered.

To apply, please send a CV, an application letter and at least one reference to Sara Marcatili: sara.marcatili@lpsc.in2p3.fr

References:

1) S. Marcatili et al., 2019, A 100 ps TOF detection system for on-line range monitoring in hadrontherapy, *2019 IEEE NSS-MIC Conference Record, 26 Oct.-2 Nov. 2019 Manchester, UK*. https://arxiv.org/abs/2001.04222
2) M. Jacquet et al., A Time-Of-Flight-Based Reconstruction for Real-Time Prompt-Gamma Imaging in Protontherapy, Phys Med Biol, 66 (2021) 135003. https://arxiv.org/abs/2012.09275
3) M. Jacquet et al., A high sensitivity Cherenkov detector for prompt gamma timing and time imaging, Scientific Report (2023) 13:3609. http://arxiv.org/abs/2309.03612