

# Position Description

## 1. General Information

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|-----------------------------------|--|
| <b>Name of the position</b>       | <b>Liquid Xenon Detector technology for astroparticle physics and medical imaging</b>  |
| <b>Foreseen date of enrolment</b> | 1 October 2023   |
| <b>Position is funded by</b>      | <ul style="list-style-type: none"> <li>• COFUND, Marie Skłodowska-Curie Actions (MSCA), Horizon Europe, European Union</li> <li>• Institut Mines Telecom (IMT) Atlantique</li> <li>• The University of Melbourne (UniMelb)</li> </ul>  |
| <b>Research Host</b>              | IMT Atlantique   |
| <b>PhD awarding institutions</b>  | IMT Atlantique & The University of Melbourne   |
| <b>Locations</b>                  | <p>Primary: Nantes, France</p> <p>Secondary: Melbourne, Australia</p>  |
| <b>Supervisors</b>                | <p>Prof. Dominique Thers (IMT /SUBATECH)</p> <p>Dr. Sara Diglio (CNRS/SUBATECH)</p> <p>A/Prof. Julien Masbou (Nantes University/SUBATECH)</p> <p>Prof. Elisabetta Barberio ( UniMelb)</p> <p>Prof. Phillip Urquijo ( UniMelb)</p> <p>Dr. Yuri Venturini (CAEN SpA)</p> <p>Dr. Alessandro Iovene (CAEN SpA)</p> |
| <b>Group of discipline</b>        | Astrophysics, Technology, Medical physics, Applied science   |

## 2. Research topics (only one of these projects will be funded)

### Project 1: *Searching for Dark Matter with Liquid Xenon Detectors*

Shedding light on the nature of dark matter is among the main priorities of particle physics, astrophysics and cosmology today. Worldwide, more than a dozen direct detection experiments are prepared to observe rare signals induced by dark matter candidates in ultra-sensitive, low-background detectors. One of the leading technologies today are dual-phase Liquid Xenon Time Projection Chambers. This project is centred around the direct search for different dark matter candidates with the currently running XENONnT experiment and the study of future perspectives with the



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next generation Liquid Xenon detectors within the XLZD collaboration. For this latter, R&D and performance studies aiming at optimizing the design of this future liquid xenon observatory will be carried on in collaboration with industrial partners.

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**Research Fields:** Astrophysics, Technology

### Project 2: *Shedding light on the nature of neutrinos with Liquid Xenon Detectors*

In the past few decades neutrinos have provided some of the most relevant discoveries in particle and astroparticle physics: measurements of their properties gave strong indications that this particle plays a central part in the evolution of our matter-dominated universe. A crucial piece of this puzzle is to establish experimentally if neutrinos, contrary to all other fermions particles, is its own antiparticle (Majorana particle) through measurements of very rare nuclear decays. With this project we aim at investigating the nature of neutrinos probing neutrinoless double beta decay ( $0\nu 2\beta$ ) in  $^{136}\text{Xe}$  and  $^{134}\text{Xe}$  with data delivered by the current running XENONnT experiment and the projection studies on the sensitivity of next generation Liquid Xenon detectors like nEXO and DARWIN. In this perspective, part of the program will be carried on in collaboration with industrial partners in order to study, build and characterize a prototype system for recovery and storage of the xenon for future larger scale experiments.

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**Research Fields:** Astrophysics, Technology

### Project 3: *Medical imaging with Liquid Xenon Detectors*

Cameras used in nuclear medical imagery should be able to reinforce the quality of the images used in order to better understand the functioning of each patient: they enable precise, three-dimensional localization of the position of certain radioactive drugs through a geometric triangulation mechanism, providing a new means of medical imaging, named "three-photon imaging". At present, a Compton telescope named XEMIS2 is being installed at Nantes University Hospital to investigate the contribution of high-energy gamma-rays detection for functional nuclear medical imaging on small animals. The first images of XEMIS2 are expected in 2023: the telescope comprising 200 kg of liquid xenon, will surround the small animal and allows the detection of gamma-rays over a very large geometric acceptance.

XEMIS2 has been optimized to reconstruct the position of the different interactions produced by the same  $\gamma$ -ray in order to be able to determine its trajectory by reconstructing the so-called Compton sequence of interactions. Moreover, the importance of the recombination process of the primary charges present at the level of each interaction could also make it possible to better identify the Compton interactions of the photoelectric interactions. We propose to study in detail this subject by using XEMIS2 data. The prospects of such detection for other types of research would also be developed. Part of this work will be carried on in collaboration with industrial partners.

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### 3. Employment Benefits and Conditions

L'École Nationale Supérieure Mines-Télécom Atlantique Bretagne - Pays de la Loire (IMT Atlantique) offers a 36-months full-time work contract (with the option to extend up to a maximum of 42 months).

The remuneration, in line with the European Commission rules for Marie Skłodowska-Curie grant holders, will consist of an annual gross salary of 30,300 EUR. Of this amount, the estimated salary to be perceived by the Researcher is 1,975 EUR net per month. However, the definite amount to be received by the Researcher is subject to national tax legislation (3.5 %).

#### Benefits include

- Access to all the necessary facilities and laboratories at IMT Atlantique (SUBATECH) and the University of Melbourne as well as LNGS and SUPL laboratories.
- Tuition fee waiver at both PhD enrolling institutions.
- Yearly travel allowance to cover flights and accommodation for participating in AUFRADE events.
- 10,000 EUR allowance to cover flights and living expenses for up to 12 months in Australia.
- 49 days paid holiday leave
  - Contractual doctoral students benefit from the paid leaves, under the same conditions as all employees of the Institut Mines-Télécom
- Sick leave
  - Serious illness leave, granted after three years' service and examination by the medical committee - provision which can only be applied in cases of contract extension beyond three years, as it is granted after three years' service (article 61-1),
  - Leave for occupational injury or illness (article 63)
  - Exceptional leave of absence for family events (article 54)
  - Ordinary sick leave with compensation based on seniority (article 60-1)
- Parental leave
  - Maternity or adoption leave (article 62)
  - Paternity leave (article 62 bis)

### 4. PhD enrolment

Successful candidates for this position will be enrolled by the following institutions and must comply with their specific entry requirements, in addition to AUFRADE's conditions.

#### IMT Atlantique

To be accepted for doctoral study in IMT's laboratories, Applicants must hold a Master of Science or Master of Engineering or another similar world-class master's degree (officially recognized as equivalent by the French Higher Education and Research authorities) is required.



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Applicants from foreign countries may have to be evaluated by French Authorities before being allowed to be hosted by IMT Atlantique. In case of denial, the employment will not be carried out.

More information: <https://www.imt.fr/en/education/our-degrees/phd/>

## The University of Melbourne

To be considered for entry, applicants must have completed:

- A 4-year undergraduate degree in a relevant discipline, including a substantial research component (equivalent to at least 25 per cent of 1 year of full-time study), with a weighted average mark (WAM) of at least 75 per cent in your final year subjects or equivalent, or
- A master's degree in a relevant discipline, including a substantial research component (equivalent to at least 25 per cent of 1 year of full-time study), with a WAM of at least 75 per cent or equivalent, or
- A qualification and professional experience considered to be equivalent.

Applicants must also meet the University's English language requirements to be eligible for entry (TOEFL Internet-based test, IELTS (Academic), Pearson Test of English or Cambridge English, Advanced/Certificate in Advanced English (CAE) as per the course-specific requirements for the corresponding Faculty or School).

More information: <https://study.unimelb.edu.au/find/courses/graduate/doctor-of-philosophy-science/entry-requirements/>



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