

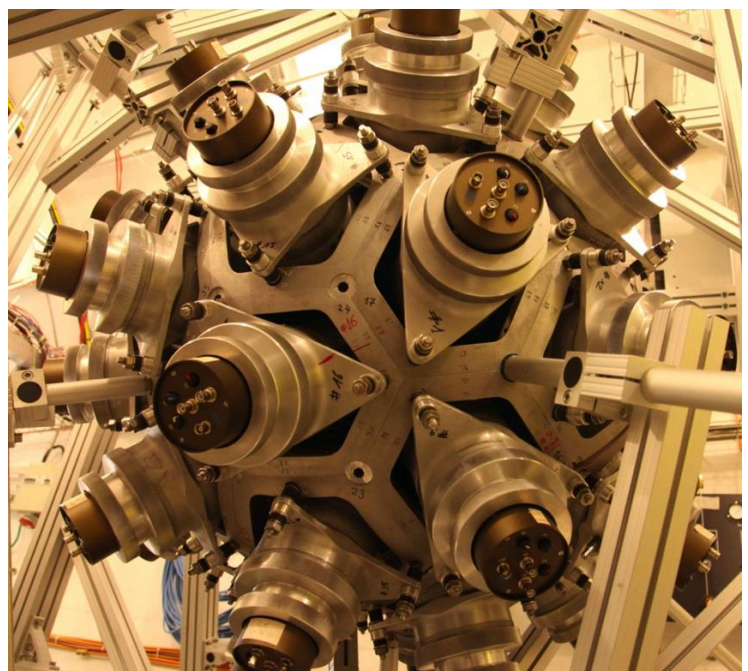


Predoctoral contract for the

## **Development of advanced technologies and methodologies for radiation detection and application to the characterisation of nuclear waste**

### **I. Introduction**

The management of the nuclear waste is one of the key aspects for the sustainability of the nuclear energy and the safety of nuclear and radioactive installations present in hospitals, industrial facilities, research facilities with particle accelerators or experimental nuclear fusion devices, among others. Nuclear waste needs to be characterised, classified and handled properly according to well established criteria. For this purpose, a series of techniques and methodologies based mainly on gamma-ray and neutron spectroscopy are being applied worldwide.



Left: MONSTER neutron spectrometer developed by CIEMAT. Right: n\_TOF total absorption gamma-ray calorimeter used at CERN for neutron capture cross section measurements.

### **II. Description of the work**

In this work we propose to apply state of art techniques and methodologies used in fundamental nuclear physics experiments for the development of innovative nuclear waste characterisation technologies. The experience of the group gained in experiments at international accelerator laboratories (CERN, JRC-Geel, GSI/FAIR) and research nuclear reactors (SCK-Mol, CEA/Cadarache, Yalina/Minsk) will serve for improving the computational tools, detection systems, data acquisition electronics and analysis methods used for the characterisation and classification of nuclear waste and other fields.

During the four years of the PhD, the young scientist will work on the following topics:

- Monte Carlo simulation. Simulation of nuclear systems, for predicting the generation of nuclear waste under different irradiation conditions. Simulation of the radiation emitted by the nuclear waste on its different forms and after different decay times. Simulation of the response of different



radiation detectors to be used for the characterisation of the nuclear waste. Sensitivity and uncertainty analysis to determine the most critical data affecting the results.

- R&D on different gamma-ray and neutron detectors. Characterisation and tests of various types of detectors (semiconductors, scintillators, proportional counters...). Conduction of experiments at CIEMAT and other national and international laboratories.
- R&D on image reconstruction methods. Development of reconstruction and analysis software.
- Data acquisition and data analysis. Detector signal reconstruction software. Evaluation of data analysis algorithms and implementation of new methodologies based on machine learning. Propagation of uncertainties in the nuclear waste packages into the final results.
- Application of the developments to the characterisation of nuclear waste.
- Evaluation of synergies of the techniques and methods developed with medical physics (imaging and particle therapy) and fundamental science applications.

### III. Framework

The research project will be carried out in close collaboration with the Spanish nuclear industry, ENUSA Industrias Avanzadas S.A. and ENRESA, as part of the SISCAREN project for the development of a new instrument for the characterisation of low and intermediate level nuclear waste. The experience gained by the pre-doctoral researcher during the 4 years of thesis will serve for continuing a successful career in nuclear science or getting a qualified job in the nuclear industry. The knowledge acquired in Monte Carlo simulation, nuclear instrumentation and data analysis is highly valued by the nuclear industry (energy, medical applications) at a national and international level. Indeed, the employment ratio of experts in nuclear technologies is close to 100%, and the renaissance of nuclear energy taking place worldwide (for the mitigation of climate change and reducing the dependence on oil and gas) will further increase the generation of high-quality jobs.

### IV. Contact and further information

For further information, all interested candidates should contact the researchers named below

Dr. Francisco Álvarez Velarde  
[Francisco.alvarez@ciemat.es](mailto:Francisco.alvarez@ciemat.es)

Dr. Daniel Cano Ott  
[daniel.cano@ciemat.es](mailto:daniel.cano@ciemat.es)