List of student internships offered by new*cleo*

–academic year–

2025–2026

January 23, 2026

Preface

This document contains the internship offers supported by *new*cleo. Each offer contains the specifications and modalities for the application and execution of the internship work.
Please submit your CV and motivation letter to the contact person indicated in the internship offer.

About *new*cleo

Privately funded and headquartered in London, *new*cleo was launched in 2021 – and since raised a total of EUR 400m – to be an innovator in the field of nuclear energy. Its mission is to generate safe, clean, economic and practically inexhaustible energy for the world, through a radically innovative combination of existing, accessible technologies.

With visionary co-founders, *new*cleo capitalises on thirty years of R&D activity in metal-cooled fast reactors and liquid-lead cooling systems, and its senior management and advisory team can boast hundreds of years in cumulative hands-on experience.

Counting on around 800 highly skilled employees across Europe, *new*cleo has business, scientific, operations and industrial manufacturing capabilities in a vertically integrated model designed to deliver its ambitious timeline for its plan-to-market.

*new*cleo's technology, mostly comprising a novel approach to already qualified solutions, addresses equally well the three challenges affecting the nuclear industry to date:

- **Waste**: fast reactors are capable of efficient "burning" (i.e., fission) of depleted uranium, plutonium and minor actinides. When operated with mixed-oxide (MOX) fuel generated from reprocessed nuclear waste, *new*cleo's reactors not only ensure sustainability by closing the fuel cycle, but can also boost energy independence;
- **Safety**: lead-cooled reactors operate at atmospheric pressure. The properties of lead (thermal capacity and conductivity, boiling point, chemically inert, low neutron activation, shielding properties) together with *new*cleo's passive safety systems ensure very high levels of safety;
- **Cost**: *new*cleo's reactor design has been optimised over the last 20 years leading to the concept of an ultra-compact and transportable 200MWe module with improvements in energy density compared to other technologies. Costs are kept low by means of simplicity, compactness, modularity, atmospheric pressure operation and elevated output temperature.

*new*cleo is also working to significantly invest in MOX fuel manufacturing in developed countries, extracting energy from the current nuclear industry by-products.

*new*cleo is ready to develop a new, sustainable, and completely safe way of generating nuclear energy that will help humanity reach zero emissions and mitigate global warming.

List of Internships

Comparison of numerical acceleration methods for nonlinear iterations used in the computer code TRANSURANUS

Elena Travaglia and Daniele Tomatis*

new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy*

January 8, 2026

– Internship proposal –
(ID No. 1003986)

Keywords — TRANSURANUS, numerical acceleration, non-linear iterations
Topics — fuel performance, numerical mathematics, computational modelling

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Location *new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy
Starting date To be defined
Duration 4–6 months

Context

*new*cleo is currently in the process of developing advanced Lead-cooled Fast Reactor (LFR) units tailored for small and modular reactors. These units incorporate innovative features aimed at addressing the unique challenges associated with LFR technology. Simultaneously, the company is committed to meeting sustainability, economic, and safety objectives, aligning with the criteria set for the fourth generation of nuclear reactors.

In the context of fuel performance analysis, newcleo relies on the TRANSURANUS (TU) thermo-mechanical computer code, which is distributed by the Joint Research Center of the European Commission in Karlsruhe, Germany, under a collaboration research agreement [1, 2]. Newcleo has initiated a meticulous examination of the code to ensure its suitability and adaptability for applications involving LFR technology. The goal is to employ precise physical models that guarantee reliable results in numerical simulations. This ongoing effort also includes improving the code to broaden its scope and enhancing its performances.

*Contact person, daniele.tomatis@newcleo.com

Description

The thermal analysis of an integral fuel rod can be treated by superposing one-dimensional radial and axial solutions. Given the multitude of non-linearities inherent in these processes, only numerical solution techniques prove feasible. These techniques are of critical importance as they determine numerical stability and, to a considerable extent, the overall computational cost.

TU solves heat transfer by the Fourier equation in the radial coordinate of the fuel rod, whose discretized form brings to a tridiagonal system. The nonlinearity of the coefficients in the second order differential equation is handled by successive substitutions. The resulting non-linear iterations are accelerated by minimizing the residuals through a numerical scheme based on Regula Falsi, initially implemented by Lassmann [3].
This procedure was adopted because calculating the temperature of a fuel rod, which is schematically shown in Fig. 1, is a computationally intensive task. Therefore, it is important to focus on obtaining convergence and minimizing the total numerical effort required.

In the current internship the student will perform a complete literature review of the existing models to solve heat conduction equation and techique to accelerate the convergence of such numerical method. Some of this techinque will be implemented and their performance will be compared.

The student will be introduced to the use of TU and will join the team of TU developers at *new*cleo, learning the best practices for collaborative work and quality-assured code development. The production of a technical report is expected at the end of the internship to describe the work done by the student and to compile the analysis of the results.

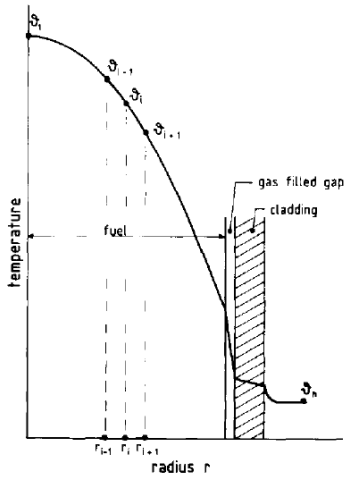

Figure 1: Schematic rappresentation of the stationary radial temperature profile in a slice of the fuel rod

Work plan

a) Litterature review and retrieval of the existing work
b) Discussion of the problem
c) Implementation and verification of the numerical solution

d) Analysis of the numerical results
e) Preparation of a technical report

Applicant profile

Master or PhD student in Nuclear, industrial or Software Engineering; Applied Physics; Mathematics.
Required computer skills: Basic knowledge of Linux operative system and software programming (previous experience in FORTRAN is appreciated, but not fundamental).
Knowledge of LaTeX editing is appreciated, but not required.

References

[1] K Lassmann. Transuranus: a fuel rod analysis code ready for use. *Journal of Nuclear Materials*, 188:295–302, 1992.

[2] K Lassmann and H Blank. Modelling of fuel rod behaviour and recent advances of the transuranus code. *Nuclear Engineering and design*, 106(3):291–313, 1988.

[3] K. Lassmann. A fast and simple iteration scheme for the temperature calculation in a fuel rod. *Nuclear Engineering and Design*, 103(2):211–214, 1987.

Analysis and verification of the burnup model implemented in the computer code TRANSURANUS

Elena Travaglia and Daniele Tomatis*

new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy*

January 8, 2026

– Internship proposal –
(ID No. 1003987)

Keywords — TRANSURANUS, Burnup model, LFR
Topics — nuclear fuel design, fuel performance and thermomechanics, computational modeling

Location	*new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy
Starting date	To be defined
Duration	5–6 months

Context

Currently, *new*cleo is designing advanced Lead-cooled nuclear Fast Reactors (LFR). These units incorporate innovative features aimed to address the unique challenges associated with the decarbonization of the energy market and reprocessing of spent nuclear fuel. Concurrently, the company is dedicated to fulfilling sustainability, economic, and safety goals, in line with the criteria established for the fourth generation of nuclear reactors.

In the domain of fuel performance analysis, *new*cleo relies on the TRANSURANUS (TU) thermo-mechanical computer code, which is provided by the Joint Research Center of the European Commission in Karlsruhe, Germany, under a collaboration agreement [1, 2]. *new*cleo is performing a thorough examination of the code to check that it can reliably reproduce the physical behavior of LFR fuel rods.

This ongoing endeavour also includes improving the code to broaden its range of applications, with a specific focus on providing trustworthy predictions for modeling LFR fuel rods. The final goal of this initiative is to develop an improved version of the code.

*Contact person, daniele.tomatis@newcleo.com

Description

The performance of a fuel rod is greatly influenced by several physical phenomena. The exposure of the fuel rod to neutron irradiation determines the time evolution of the isotopic concentrations, and of the power density distribution within the fuel. The power density is the main driving force of the local temperature profile. The temperature heavily affects material properties and many physical phenomena, such as fuel restructuring, actinide redistribution, fission gas release, creep of fuel and cladding [1, 2]. A thorough description of the time evolution of the isotopic concentration of heavy metals in the fuel is thus crucial. Accordingly, one of the first stages in describing fuel rod behaviour is to compute at each radial position in the fuel: the local burnup, the build-up of heavy metal nuclides and the formation of fission products. The equations used to describe these phenomena constitute the so-called burnup models.

A model called TUBRNP, developed by Lassmann in 1994 [3], is implemented in TU. This model predicts the radial power density distribution based on burnup together with the radial profiles of actinide concentrations.

During the internship, the student will study and verify the implementation of the simplified burnup model. In particular, it will be requested to revise the implementation of the calculation of the radial neutron flux distribution in the fuel slices that is currently preventing the use of user-input distributions.

In addition, to assess the physical consistency of the isotopic composition evolution in case of anomalous behavior, a parallel inventory analysis of LFR fuel rods will be performed using the depletion module of the OpenMC Monte Carlo code.

The student will be introduced to the use of TU for the calculation of fuel rods used in nuclear reactors. He/she will join the team of TU developers at *new*cleo where he will learn effective collaborative practices and methods for developing code with ensured quality. At the conclusion of the internship, the student is expected to produce a technical report detailing his/her contributions and experiences during the internship period.

Work plan

a) Literature review and retrieval of the existing work relating to TUBRNP
b) Code implementation
c) Analysis of the results
d) Preparation of a technical report

Applicant profile

Master or PhD student in Nuclear, Industrial or Software Engineering; Applied Physics
Computer skills: FORTRAN, Linux.
Knowledge of LaTeX editing is appreciated, but not required.

References

[1] K Lassmann. Transuranus: a fuel rod analysis code ready for use. *Journal of Nuclear Materials*, 188:295–302, 1992.

[2] K Lassmann and H Blank. Modelling of fuel rod behaviour and recent advances of the transuranus code. *Nuclear Engineering and design*, 106(3):291–313, 1988.

[3] K. Lassmann, C. O'Carroll, J. van de Laar, and C.T. Walker. The radial distribution of plutonium in high burnup uo2 fuels. *Journal of Nuclear Materials*, 208(3):223–231, 1994.

Cross section preparation for LFR by Monte Carlo computer codes

Gianluca Cirillo*[1] and Daniele Tomatis[1]

[1]new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy*

January 8, 2026

– Internship proposal –
(ID No. 1008549)

Keywords — LFR, OpenMC, cross section preparation
Topics — Physical modelling, neutron transport, reactor physics

Location	*new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy
Starting date	To be defined
Duration	5 months

Context

*new*cleo is designing small lead fast reactors (LFR) operating in a pool that contains all the primary system components. Cooling is done by molten lead which shields photon radiation and has low neutron absorption.

The core can show high heterogeneity to meet the criteria of compactness, target neutron leakage and power shape, breeding or burning features. The core is made of a main active zone, possibly surrounded by a shielding or breeding blanket.

Although computer simulation by Monte Carlo codes like OpenMC [1] allows today to carefully represent many details of the reactor, simplified calculation schemes relying on homogenization theory and equivalence theory must still be adopted to perform faster core calculations [2, 3], thus easing the whole design process. During this internship, the student will prepare homogenized cross sections by OpenMC and use them after to perform calculations with the deterministic full-core codes VARIANT [4] and DONJON [5].

*Contact person, gianluca.cirillo@newcleo.com

Description

Deterministic computer codes allows fast neutron calculations and are largely employed in reactor physics and analysis. They rely on assumptions and approximations that must be carefully verified and validated. For instance, using lattice calculations of fuel elements in fundamental mode neglects the environment effects and the local core conditions, introducing sometimes an inconvenient limitation in the calculation scheme. Provided that the material inventory of all fuel elements is known, the Monte Carlo simulation can be used to overcome this limitation, yet paying a higher computational cost.

A new feature in the code OpenMC to prepare homogenized cross sections on hexagonal grids is currently under development and it will be tested during this internship, together with a reduced nuclide chain suitable to lead fast reactors. After, a suitable interface will be developed to load the set of homogenized data into VARIANT and DONJON, which use different solution methods to obtain the neutron flux distribution over the full core. These codes use low-order transport methods, with a lower computational effort. Besides, the core configurations calculated by OpenMC and used for detailed cross section preparation will allow to assess the performance of low-order transport solutions. The setup of the calculation input files and the interfaces will be performed on git version control. Finally, the candidate will produce a technical report at the end of the internship to compile the results, by quantifying the gain in runtime obtained while using the deterministic codes and by assessing the performance in physical accuracy and numerical precision.

Work plan

a) Literature review and study of homogenization and equivalence theory.
b) Training and practice with the computer codes.
c) Setup of the core model by OpenMC.
d) Preparation of the cross section model.
e) Setup of the core calculations.
f) Analysis of results and preparation of the final report.

Applicant profile

Master student in Nuclear Engineering or student in Applied Mathematics and Physics.
Background: fundamentals in applied mathematics and the physics of nuclear reactors.
Required computer skills: Linux, Python (intermediate), LaTeX scientific editing (optional).

References

[1] P. K. Romano, N. E. Horelik, B. R. Herman, A. G. Nelson, B. Forget, and K. Smith. Openmc: A state-of-the-art monte carlo code for research and development. *Annals of Nuclear Energy*, 82:90–97, 2015.

[2] George I Bell and Samuel Glasstone. *Nuclear reactor theory*. US Atomic Energy Commission, Washington, DC (United States), 1970.

[3] J. R. Lamarsh and A. J. Baratta. *Introduction to Nuclear Engineering. 2nd Edition*. Addison-Wesley, Reading, 1983.

[4] Gérald Rimpault, Danièle Plisson, Jean Tommasi, Robert Jacqmin, Jean-Marie Rieunier, Denis Verrier, and Didier Biron. The ERANOS code and data system for fast reactor neutronic analyses. In *PHYSOR 2002-International Conference on the New Frontiers of Nuclear Technology: Reactor Physics, Safety and High-Performance Computing*, 2002.

[5] A Hébert. DRAGON and DONJON: a legacy open-source reactor physics project at Polytechnique Montréal. In *Proceedings of the IAEA Technical Meeting on the Development and Application of Open-Source Modelling and Simulation Tools for Nuclear Reactors, Milano, Italy, June*, 2022.

Refactoring and optimization of DASSH subchannel code

Gabriele Ottino*[1], Francesco Pepe[1,2], and Daniele Tomatis[1]

[1] new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy*
[2] *Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 Torino, Italy*

January 14, 2026

– Internship proposal –
(ID No. 1009187)

***Keywords* —** LMFR, Subchannel code, Python
***Topics* —** Code development, heat transfer, thermal-hydraulics, numerical simulation

Location	*new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy
Starting date	As soon as possible
Duration	6 months

Context

The accurate and fast prediction of thermal-hydraulic behavior of nuclear reactor cores is essential to support and speed up the design activities of Lead-cooled Fast Reactors (LFR). Subchannel codes play a key role in modeling coolant flow, pressure drop, and heat transfer phenomena both in single assemblies and at the core level. Among the others, DASSH ([1], [2], [3]) is a Python-based code originally developed at the Argonne National Laboratory (IL, USA). Currently, *new*cleo is actively developing it to expand its range of application to include the conditions in which its reactors operate. As the models used in DASSH become more complex, improving its computational performance together with its reliability, maintainability and readability has become a priority. The refactoring of the code is then under evaluation, including the possible use of faster compiled languages like Fortran 2018 or C++ to rewrite some critical sections of the code.

Description

DASSH is a Python-based subchannel code originally used for the steady-state thermal-hydraulic analysis of reactor cores, particularly in liquid metal-cooled fast reactors. The original version of

*Contact person, gabriele.ottino@newcleo.com

the code, developed at the Argonne National Laboratory, is open-source and can be downloaded from `https://github.com/dassh-dev/dassh.git`. *new*cleo has forked the original repository (`https://github.com/newcleo-dev-team/dassh_nc`) to introduce new advanced features, to improve the code accuracy and to extend its application domain. Although Python ([4], [5]) ensures rapid development and code readability, it could introduce performance limitations when applied to large, computationally demanding problems.

The aim of this internship is to refactor from scratch DASSH code with the aim of improving its readability, maintainability and computational performance. After gathering a deep insight of the current architecture, the candidate will identify the portions of the code that significantly impact the code runtime. Following this diagnostic phase, optimization strategies will be considered and implemented. These may include:

- integration with modules written in C++ or Fortran 2018, that will substitute the computationally most expensive portions of the code;
- adoption of parallelization techniques whenever useful;
- refactoring of some of the already existing Python classes.

During the implementation phase, it will be necessary to ensure that any optimization does not affect the accuracy of the original code, thus updating and/or integrating the test suite accordingly. The refactoring activity will include also the setup of the automatic documentation framework, with the aim of limiting as most as possible any inconsistency between the base code and its manual.

The activity will be carried out under the supervision of the Codes and Methods team at *new*cleo.

Work plan

a) Analysis of the original code architecture and identification of the most critical sections.
b) Definition of a more suitable code architecture.
c) Code implementation.
d) Update and integration of the test suite, possibly exploiting CI/CD pipelines.
e) Setup of the automatic documentation framework.
f) Preparation of a technical report.

Applicant profile

Master student in Industrial Engineering, Computer Engineering or Computer Science.
Skills and backgroung:

- Basic knowledge of object-oriented software programming (Python, Fortran 2018, C/C++);
- Basic knowledge of Linux OS;
- Fundamentals in thermo-fluid dynamics and numerical simulations (appreciated, but not fundamental).

Nice to have: experience using Git and LaTeX. Basic knowledge of liquid metal-cooled fast reactors.

References

[1] Milos Atz, Micheal Smith, and Florent Heidet. Dassh software for ducted assembly thermal hydraulics calculations - overview and benchmark. 2020.

[2] Milos Atz, Micheal A. Smith, and Florent Heidet. *Ducted Assembly Steady State Heat Transfer Software (DASSH) - Theory Manual*. ANL/NSE-21/33, Argonne National Laboratory, 2021.

[3] Milos Atz, Micheal A. Smith, and Florent Heidet. *Ducted Assembly Steady State Heat Transfer Software (DASSH) - User Guide*. ANL/NSE-21/34, Argonne National Laboratory, 2021.

[4] Lutz Mark. *Learning Python: Powerful Object-Oriented Programming*. O'Reilly Media, Sebatopol, USA, 5 edition, 2013.

[5] Giridhar Chetan. *Learning Python Design Patterns*. Packt Publishing, Birmingham - Mumbai, 2 edition, 2016.

Implementation of Helium Contribution to the Fission Gas Swelling and Release Model in the Computer Code TRANSURANUS

Daniele Tomatis*[1] and Andrea Croci[1]

[1]new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy*

January 14, 2026

– Internship proposal –
(ID No. 1009581)

Keywords — Helium, Fission Gas Release, Swelling, TRANSURANUS
Topics — nuclear fuel design, fuel performance and thermomechanics, computational modelling

Location	*new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy
Starting date	October 2025
Duration	6 months

Context

*new*cleo is designing an advanced small modular Lead-cooled Fast Reactor (LFR). To perform the fuel performance analysis, *new*cleo relies on the TRANSURANUS (TU) thermo-mechanical computer code, which is provided by the Joint Research Centre of the European Commission in Karlsruhe, Germany, under a collaboration agreement [1, 2]. *new*cleo is currently carrying out a verification and validation of the code to check that it can reliably reproduce the physical behaviour of Mixed Oxide (MOX) fuel rods for LFR usage. This ongoing endeavour also includes improving the code to broaden its range of applications, with a specific focus on providing trustworthy predictions for modelling LFR fuel rods. The final goal of this initiative is to develop an improved version of the code.

Description

Among the many phenomena that occur in a fuel pin under irradiation, Fission Gas Release (FGR) and Fission Gas Swelling (FGS) are fundamental to be correctly modelled in a fuel performance code. They are the result of a continuous production of Fission Gas (FG) atoms,

*Contact person, daniele.tomatis@newcleo.com

such as Xenon (Xe) and Krypton (Kr), and other gases like Helium (He), that accumulate in the fuel matrix. This causes volume increase (swelling) and, under certain conditions, such gases can be released into pin's free volume [3] leading to degradation of the thermal conductivity of the fuel rod filling gas (usually He) and increase of the internal fuel rod pressure. These effects reduce the safety margins for the mechanical resistance of the cladding. TU implements a physics-based model to deal with FGR and FGS [4, 5, 6] , which, however, does not consider the contribution of He to the gas release and swelling. Commonly employed oxide fuels, especially MOX, produce He through α decay of heavy nuclides and ternary fissions, contributing to the increased internal rod pressure at high burnup levels [7]. In view of its importance for MOX fuels, the inclusion of He in the physics-based model is of great interest.
In this internship, the student will perform a complete literature review of the existing models for FG behaviour, focusing on He and then, he/she will implement in TU all the necessary code changes to include the contribution of He to the swelling and release. Finally, the code will be tested against available experimental data. The student will be introduced to using TU for fuel performance analysis and will become part of the TU development team at *new*cleo, where they will learn best practices for collaborative development and producing high-quality, reliable code. At the end of the internship, the student is expected to produce a technical report detailing their work and presenting an analysis of the results.

Work plan

a) Literature review on FG behaviour in oxide and MOX fuels
b) Code implementation, verification and test
c) Analysis of the results
d) Preparation of a technical report

Applicant profile

Master student in Nuclear, Mechanical or Energy Engineering; Applied Physics.
Computer skills: FORTRAN, Linux, Python.
Knowledge of LATEX editing is appreciated, but not required.

References

[1] K. Lassmann. Transuranus: a fuel rod analysis code ready for use. *Journal of Nuclear Materials*, 188:295–302, 1992.

[2] K.Lassmann and H. Benk. Modelling of fuel rod behaviour and recent advances of the transurauns code. *Nuclear Engineering and Design*, 106(3):291–313, 1998.

[3] K. Lassmann and H. Benk. Numerical algorithms for intragranular fission gas release. *Journal of Nuclear Materials*, 280(2):127–135, 2000.

[4] Giovanni Pastore. *Modelling of Fission Gas Swelling and Release in Oxide Nuclear Fuel and Application to the TRANSURANUS Code*. Doctoral dissertation, Politecnico di Milano, Department of Energy, 2012.

[5] Giovanni Pastore, Lelio Luzzi, Valentino Di Marcello, and Paul Van Uffelen. Physics-based modelling of fission gas swelling and release in uo2 applied to integral fuel rod analysis. *Nuclear Engineering and Design*, 256:75–86, 2013.

[6] Giovanni Pastore, L.P. Swiler, J.D. Hales, S.R. Novascone, D.M. Perez, B.W. Spencer, L. Luzzi, P. Van Uffelen, and R.L. Williamson. Uncertainty and sensitivity analysis of fission gas behavior in engineering-scale fuel modeling. *Journal of Nuclear Materials*, 456:398–408, 2015.

[7] K. Katsuyama, T. Mitsugi, and T. Asaga. Evaluation of helium release behavior in mox fuel. In *Proceedings of the 1998 ANS Winter Meeting*, pages 115–116, Washington, D.C., 1998. Materials Science and Technology session.

Numerical study of Fuel Assembly deformations in LFR

Andrea Lario*[1] and Gabriele Ottino[1]

[1]new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy*

January 22, 2026

– Internship proposal –
(ID No. 1010756)

***Keywords* —** Beam models, FEM, structural deformations
***Topics* —** Structural mechanics, beam theory

Location *new*cleo S.p.A., Corso Stati Uniti 38, 10128, Torino, Italy
Starting date Second quarter of 2026
Duration 5–6 months

Context

To design an inherently safe Lead-cooled Fast Reactor (LFR), it is crucial to predict mechanical deformations accurately since changes in the spacing between neighbouring fuel assemblies (FAs) can result in altered neutron production and absorption, thus affecting the overall reactivity. Accurate prediction of FA deformations can be achieved by using structural computational tools based on Finite Element Methods (FEMs). However, their intrinsically high computational cost and the need to perform many calculations to solve the coupling between neutronics and thermal-hydraulics limit their application in ordinary design work. An alternative approach is based on simplified 1D methods, which approximate each FA as a beam element. While this is a considerable simplification, when applied to nuclear core reactors it retains most of the physical phenomena that are of interest for investigation and ensures fast predictions, requiring a limited number of input parameters. There are only a few scientific tools available for analysing FA deformation in core reactors that are based on 1D tools [1, 2]. The goal is to develop a scientific computational tool based on 1D beam elements for design and safety calculations, accepting some degree of approximation in the solution.

*Contact person: andrea.lario@newcleo.com

Description

Both elastic and inelastic deformations affect the shape of fuel assemblies in a reactor core. These deformations are driven by various factors; in particular, high thermal gradients induce bowing, while irradiation and stress induce the inelastic effects of creep and swelling. Additionally, local forces acting on an assembly can arise when FAs come into contact with each other.

The aim of the internship is to investigate the deformation of fuel assemblies when subjected to elastic and inelastic deformations. The investigation will be carried out by using models of different accuracy and detail. After gaining an in-depth understanding of the existing literature, the candidate will identify the most suitable models and range of parameters for describing the configurations of interest at *new*cleo in terms of, for example, geometry, temperature gradients, irradiation and materials.

Beam models based on Bernoulli or Timoshenko theory will be implemented, and their predictions will be compared with analytical solutions (whenever available) or results produced with FEM solvers for structural mechanics.

Expected results include: a comparison between the considered models; the identification of the parameters that most affect the deformation of fuel assemblies; the evaluation of modelling the single phenomena involved; the study of the mutual interaction among these phenomena.

This work will be carried out under the supervision of the Codes and Methods team at *new*cleo.

Work plan

(a) Provide a comprehensive review of the literature;
(b) Identify the relevant physical phenomena and aspects of newcleo's LFR core and fuel elements;
(c) Select test configurations and compare the results provided by models of different accuracy;
(d) Perform parametric studies to identify the factors that have the greatest influence on the results and to assess the effects introduced by simplifications;
(e) Prepare a technical report.

Applicant profile

Master student in Nuclear Engineering, Civil Engineering, Aerospace Engineering or Mechanical Engineering. Skills and background:

- Basic knowledge of software programming (Python/FORTRAN 2018 are appreciated);
- Basic knowledge of Linux OS;
- Fundamentals in numerical simulations;
- Knowledge of Finite Element Method software for structural mechanics, either commercial or open-source.

Nice to have: experience using LaTeX. Basic knowledge of liquid metal-cooled fast reactors.

References

[1] Nicholas Wozniak, Emily R. Shemon, and James J. Grudzinski. Review of tools for modeling core radial expansion in liquid metal-cooled fast reactors. Technical report, Argonne National Laboratory (ANL), Argonne, IL (United States), Nov. 2020.

[2] G. A. McLennan NUBOW: a FORTRAN-IV program for the static elastic structural analysis of bowed reactor cores Technical report, Argonne National Laboratory (ANL), Argonne, IL (United States), Apr. 1974.

References

Beam-to-beam contacts for modelling Fuel Assembly interactions in LFR

Andrea Lario*[1] and Gabriele Ottino[1]

[1]new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy*

January 22, 2026

– Internship proposal –
(ID No. 1010757)

Keywords — Contact model, structural deformations, numerical modelling
Topics — Structural mechanics, beam theory

Location	Corso Stati Uniti 38, 10128, Torino, Italy
Starting date	Second quarter of 2026
Duration	5–6 months

Context

Mechanical deformation of the core structures causes relevant reactivity feedback in fast reactors. Accurate prediction of the geometry modifications and of their positioning into the core can be obtained by using structural computational tools based on Finite Element Methods (FEMs). However, the high computational cost of these tools and the need to perform many calculations to solve the coupling between neutronics and thermal-hydraulics limit their application in ordinary design work. To overcome these limitations, simplified mechanical models with lower computational effort should be used. These approaches, based on 1D beam theory, trade computational speeds for accuracy, but they still describe the phenomena (thermal bowing, creep, swelling, and contacts) which contribute the most to the mechanical deformation of the FAs. There are only a few scientific tools available for analysing FA deformation in core reactors that are based on 1D tools [1, 2].

The goal of the research is to develop a scientific computational tool that can predict fast the deformation of fuel assemblies by considering the reciprocal forces acting on the contacting beams.

*Contact person andrea.lario@newcleo.com

Description

Significant deformations due to both elastic and inelastic effects can result in bowed FAs coming into contact with each other during the operative life of the fuel assembly.

The fact that fuel assemblies can either be in contact or have clearances introduces non-linearities in the system of equations which describe the mechanical behaviour of the core, making ordinary linear mathematical techniques inapplicable. On the other hand, iterative solvers could be computationally expensive or lack stability.

The internship aims at studying an efficient and robust numerical techniques for solving contacts among FAs approximated as 1D beams.

After gathering a deep insight of the works available in the literature identifying appropriate test cases, the candidate will select suitable methods to solve the contacts efficiently and robustly. Two distinct models shall be possibly developed:

- simplified 2D contact model, which will be used to predict the deformation of FAs when they mutually come into contact;
- possible extension of the model to 3D geometry.

In both cases results will be compared against data available in the literature or obtained using FEM-based codes for structural analysis. Codes will be written in both Fortran 2018 and Python.

The activity will be carried out under the supervision of the *Codes and Methods* team at *new*cleo.

Work plan

(a) Provide a comprehensive literature review;
(b) Select the best methods for solving contacts occuring when beam elements come in contacts;
(c) Identify proper test cases;
(d) Implement and verify the selected methods, focusing on numerical robustness and efficiency;
(e) Prepare a technical report.

Applicant profile

Master student in Nuclear Engineering, Civil Engineering, Aerospace Engineering or Mechanical Engineering. Skills and background:

- Basic knowledge of software programming (Python/FORTRAN 2018 are appreciated);
- Basic knowledge of Linux OS;
- Fundamentals in numerical simulations and numerical analysis.

Nice to have: experience using Git and LaTeX. Basic knowledge of liquid metal-cooled fast reactors.

References

[1] Nicholas Wozniak, Emily R. Shemon, and James J. Grudzinski. Review of tools for modeling core radial expansion in liquid metal-cooled fast reactors. Technical report, Argonne National Laboratory (ANL), Argonne, IL (United States), Nov. 2020.

[2] G. A. McLennan NUBOW: a FORTRAN-IV program for the static elastic structural analysis of bowed reactor cores Technical report, Argonne National Laboratory (ANL), Argonne, IL (United States), Apr. 1974.

References

Full-core calculation of LFR for maritime applications

Gianluca Cirillo[1] and Daniele Tomatis [*1]

[1]new*cleo, Corso Stati Uniti 38, 10128 Torino, Italy*

December 12, 2025

– Internship proposal –
(ID No. 1010758)

Keywords — LFR, DRAGON-DONJON, deterministic neutron transport, core cycle.
Topics — Reactor physics, core analysis and design, fuel management.

Location	Turin office, Italy or Saclay office, France
Starting date	Beginning of 2026
Duration	6 months

Context

*new*cleo is developing innovative small modular reactors based on lead-cooled fast reactor (LFR) technology. A sealed unit intended for long-term extended operation is currently under study for ship propulsion and remote/off-shore power generation. The internship focuses on the setup of an advanced calculation scheme for this LFR unit by the deterministic computer codes DRAGON5/DONJON [1], with comparison against the Monte Carlo computer code OpenMC [2] for performance assessment.

Description

The reactor considered in this work is of the sealed type seeking inherent safety by means of passive cooling systems and employing robust materials to ensure long-term reliability, as in [3, 4]. Continuous reactor operation for at least 20 years is targeted. Excess reactivity control at beginning of cycle is achieved by means of fertile elements and burnable absorbers.

The internship focuses on full-core neutron calculations of liquid lead fast reactors (LFRs) using the deterministic codes DRAGON/DONJON. Calculations are in eigenvalue mode to reproduce operation in critical state by control elements progressively inserted over time. The feasibility of using different types of control elements will be investigated. The calculations will

[*]Contact person, daniele.tomatis@newcleo.com

be performed with assumed distributions of temperature and thermal expansion for geometry deformation.

Several calculations are necessary to find optimal configurations for reactor design, which limits the applicability of the Monte Carlo method indeed. The use of fast deterministic methods is then essential in the engineering framework.

During the internship, the student will be introduced to the physics and engineering of the LFR reactors, acquiring notions and developing skills in deterministic transport methods and neutral particle transport [5]. The student will become a proficient user of DRAGON/DONJON and will improve his/her Python programming to perform post-processing and analysis of simulation results. At the end of the internship, the student will write a technical report on the analysis of the results from the numerical simulations. The student will be followed by members of the Codes and Methods group of *new*cleo.

Work plan

During the internship, the student will be introduced to open-source transport computer codes for modeling LFR reactors and calculating maps of the released thermal power.

The student will contribute to the setup of an industrial calculation scheme suitable for fast reactor physics. These include the theoretical aspects underlying particle transport simulation and adequate modeling of the fuel elements.

The expected working plan is detailed in the following:

a) Literature review on off-grid and long-term reactors
b) Discussion of target key performance parameters
c) DRAGON/DONJON introduction and training
d) Setup of the LFR full reactor model
e) Analysis of the results
f) Preparation of a technical report

Applicant profile

Master or PhD student in Nuclear Engineering, Applied Mathematics and Physics.
Background: fundamentals in reactor physics and Monte Carlo methods.
Required computer skills: A good knowledge of Python and Linux operating systems (or willingness to learn). Knowledge of LaTeX editing is appreciated.

References

[1] Guy Marleau, Alain Hébert, and Robert Roy. A user guide for dragon version 5, 2025.

[2] Paul K. Romano, Nicholas E. Horelik, Bryan R. Herman, Adam G. Nelson, Benoit Forget, and Kord Smith. Openmc: A state-of-the-art monte carlo code for research and development. *Annals of Nuclear Energy*, 82:90–97, 2015. Joint International Conference on Supercomputing in Nuclear Applications and Monte Carlo 2013, SNA + MC 2013. Pluri- and Trans-disciplinarity, Towards New Modeling and Numerical Simulation Paradigms.

[3] J. Wallenius, S. Qvist, I. Mickus, S. Bortot, P. Szakalos, and J. Ejenstam. Design of sealer, a very small lead-cooled reactor for commercial power production in off-grid applications. *Nuclear Engineering and Design*, 338:23–33, 2018.

[4] Keith E Holbert. A review of maritime nuclear reactor systems. *Journal of Nuclear Engineering*, 6(1):5, 2025.

[5] George I Bell and Samuel Glasstone. *Nuclear reactor theory*. US Atomic Energy Commission, Washington, DC (United States), 1970.

[6] Alain Hébert. *Applied reactor physics*. Presses inter Polytechnique, 2009.

Interpretation of experiments for LFR V and V

Alex Aimetta*[1], Darian Andrés Olivares[1], and Sigtryggur Hauksson[2]

[1]new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy*
[2]*newcleo SA, EDF Lab, 7 Bd Gaspard Monge, 91120 Palaiseau, France*

January 14, 2026

– Internship proposal –
(ID No. 1010900)

***Keywords* —** Reactivity, neutron flux, validation, LFR
***Topics* —** Reactor physics and analysis, core design

Location	*new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy
Starting date	To be defined
Duration	5–6 months

Context

*new*cleo is designing a Lead-cooled Fast Reactor (LFR) with innovative features which contribute to the sustainability, economic and safety goals required for the future fourth generation nuclear reactors. The process of licencing must contain Verification and Validation (V&V) of the SCTs (Scientific Computing Tools) utilised in the design of LFRs, in order to ensure the correct estimation of the reactor parameters. The process of V&V consists in quantifying a certain physical parameter (for instance, reactivity, neutron flux spectra and spatial distribution [5]) of a reactor model and compare the result obtained by the SCT with experimental measurements done in a nuclear facility. The aim of this is to quantify the uncertainty in calculations of the physical parameters with the SCT, composed of different sources that should be identified and quantified, including the contribution of uncertainty in nuclear data. Finally, if the validation is performed for experimental models which differ from *new*cleo's LFRs, a transposition [4] of the results is needed, explaining how the validation of the SCTs apply to our scope of utilisation.

In this internship, the student will develop a specific model of the V&V section of a set of physical parameters (reactivity, neutron flux spectra and spatial distributions) with uncertainty quantification of all variables of interest and transposition to the *new*cleo's LFRs domain.

*Contact person, alex.aimetta@newcleo.com

Description

The aim of this internship is to carry out the V&V of reactor parameters such as reactivity, neutron flux spectra and spatial distributions in the Monte Carlo framework for one or two experiments representing specific scenarios. This consists in developing the models in the SCTs (e.g., OpenMC [8] and SERPENT [6]), to calculate variables of interest in the setup of given experiments. The models were already selected from international databases due to their good representativity of LFRs and listed in a V&V Plan [7]. These models have been already selected:

- The Los Alamos spheres [3], which are characterized by different fuel compositions (either enriched U or Pu) and reflectors (made of uranium, lead, or absent), could provide information on the reflector gain and the cross sections for different heavy metal isotopes.
- The BFS-61 experiment [2] is particularly valuable due to its use of lead as both a coolant and a reflector, providing direct insight of spectral effects and neutron reflection characteristic of LFR cores.

Then, a Sensitivity Analysis & Uncertainty Quantification (SA&UQ) should be done exploiting the Generalized Perturbation theory (GPT) implemented in SERPENT through the collision history approach [1] propagating the uncertainty from nuclear data libraries. Also, other sources of uncertainty can be identified, such as temperature, burnup, etc. To apply the results to *new*cleo's LFRs, the validation must be transposed to the domain of interest by analysing quantitatively similarity and representativity coefficients between our units and the experimental benchmarks, taking into account scaling effects and different coolants. Finally, this work should be documented in a report.

Work plan

a) Familiarization with the Monte Carlo codes,
b) Literature review of the selected benchmarks,
c) Literature review of the uncertainty quantification and the transposition,
d) Model implementation,
e) Calculation of the variables of interest,
f) Uncertainty quantification and transposition to LFRs,
g) Preparation of a technical report.

Applicant profile

Master student in Nuclear Engineering or Student in Applied Mathematics and Physics.
Background: fundamentals in neutron physics and reactor physics.
Required computer skills: Knowledge of OpenMC or SERPENT (optional), experience in Pyhton and LaTeX editing is appreciated.

References

[1] M. Aufiero, A. Bidaud, M. Hursin, J. Leppänen, G. Palmiotti, S. Pelloni, and P. Rubiolo. A collision history-based approach to sensitivity/perturbation calculations in the continuous energy Monte Carlo code SERPENT. *Ann. Nucl. Energy 85, 245-258*, 2015.

[2] J. B. Briggs, E. Sartori, and L. Scott. The International Reactor Physics Experiment Evaluation Project (IRPhEP). *Canadian Nuclear Society Bulletin*, 28(2):p. 31–33, Jun 2007.

[3] J. B. Briggs, L. Scott, and A. Nouri. The International Criticality Safety Benchmark Evaluation Project (ICSBEP). *Nuclear Science and Engineering*, 145(1):1–10, 2003.

[4] C. Herer. ASN/IRSN guide 28: Qualification of scientific computing tools used in the nuclear safety case – 1st barrier. *Nuclear Engineering and Design*, 405:112221, 2023.

[5] J. R. Lamarsh and A. J. Baratta. *Introduction to Nuclear Engineering. 2nd Edition*. Addison-Wesley, 1983.

[6] J. Leppänen, V. Valtavirta, A. Rintala, and R. Tuominen. Status of Serpent Monte Carlo code in 2024. *EPJ - Nuclear Sciences & Technologies*, 11, 2025.

[7] G. Rimpault, M. Falabino, V. Peluso, V. Fabrizio, and D. Tomatis. Verification and Validation (VV) Plan for neutronic computing tools used for the design of newcleo's LFRs. *PHYSOR 2026 - The International Conference on Physics of Reactors. Torino, Italy. (To be presented)*, 2026.

[8] P. K. Romano, N. E. Horelik, B. R. Herman, A. G. Nelson, B. Forget, and K. Smith. OpenMC: A state-of-the-art Monte Carlo code for research and development. *Annals of Nuclear Energy, volume 82, pp. 90-97*, 2015.

Development and Validation of an Inherent Neutron Source Code

Matteo Zammataro [*1], Ilaria Calsalbore[2], and Sigtryggur Hauksson[3]

[1,2]new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy*
[3]new*cleo SA, EDF Lab Paris-Saclay, Bd Gaspard Monge, 91120 Palaiseau, France*

January 14, 2026

– Internship proposal –
(ID No. 1011110)

Keywords — Inherent neutron sources, (α,n) reactions, spontaneous fissions
Topics — Particle physics, code development, verification & validation

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Location *new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy
Starting date First/second quarter 2026
Duration 5–6 months

Context

*new*cleo is developing a new generation of small modular lead-cooled fast reactors (LFRs), with the goal of improving fuel utilization, reducing high-level waste, and enabling closed fuel cycles. In this context, it is critical to have reliable, quantitative data about all inherent neutron sources in fuels under design or use, since these sources have an impact on safety and radiation protection, especially under accident or handling scenarios.

Inherent neutron sources typically arise from spontaneous fission and (α, n) reactions, with a smaller contribution from delayed neutron emission. Existing computational tools for estimating these sources, such as [2], exhibit limitations in flexibility, data-library compatibility, and they are not validated for fast-spectrum reactor applications.

This internship focuses on the development of an alternative computational tool for inherent neutron sources calculation and on the identification and analysis of experimental data suitable for its validation.

[*]Contact person, matteo.zammataro@newcleo.com

Description

The design of a new reactor unit requires a clear and reliable assessment of the inherent neutron sources generated within the nuclear fuel under different irradiation conditions. These sources influence every phase of reactor life: during start-up their characterization is needed to size and justify the external start-up neutron source; during shutdown, spontaneous emissions meaningfully contribute to the residual neutron flux; and in post-irradiation fuel handling and disposal, accurate neutron source assessments are crucial for radiation protection evaluations.

Inherent neutron sources arise mainly from three phenomena: spontaneous fission, (α, n) reactions and, marginally, delayed neutron emission [1]. While contributions related to delayed neutron emission are typically negligible, spontaneous fission and (α, n) reactions provide source terms that cannot be ignored.

Although scientific codes exist to estimate these neutron sources, most show limitations in structure, robustness, and compatibility with modern nuclear data libraries. Furthermore, no dedicated validation effort has yet been carried out for fast-reactor applications.

In this internship, the student will contribute to the development of a scientific computer tool for the calculation of inherent neutron sources. The work will also involve identifying and analyzing experimental data to support the validation of the developed code. As part of the activity, the student will review the state-of-the-art tools that already exist [2], identify their limitations, and implement strategic improvements. This will provide hands-on experience with programming languages like Fortran and Python, exposure to numerical methods, and allow the student to become familiar with modern software-development good practices. The results of this work will improve the robustness of inherent neutron source calculations, improving confidence in neutronics, safety, and radiation-protection analyses. The internship will be carried out under the supervision of the Codes & Methods group at *new*cleo.

Work plan

The internship will involve both theoretical and practical work, combining the study of the underlying physics of α particles transport, spontaneous fissions and (α, n) reactions with applied numerical methods and scientific programming. The student will learn how to use modern DevOps platforms, such as Git, and improve his knowledge of Fortran and Python.
The expected working plan is as follows:

a) Literature review and study of the main physical phenomena.
b) Training with SOURCES4C.
c) Identification of the limitations and discussion of possible improvements.
d) Contribution to the development of a new tool for inherent neutron sources calculation.
e) Identification of experimental data for code validation.
f) Preparation of the final report.

Applicant profile

Master student in Nuclear Engineering or student in Applied Mathematics and Physics.
Background: fundamentals in nuclear physics and applied mathematics.
Required computer skills: Linux, Python (intermediate), Fortran (nice to have) LaTeX scientific editing (optional).

References

[1] Rui-Min Ji, Cheng-Gang Yu, Ming-Hai Li, Rui Yan, Yang Zou, and Gui-Min Liu. Study on inherent neutron sources in MSR. *Nuclear Science and Techniques*, 29:47, 2018.

[2] W.B. Wilson, R.T. Perry, W.S. Charlton, and T.A. Parish. Sources: A code for calculating (alpha, n), spontaneous fission, and delayed neutron sources and spectra. *Progress in Nuclear Energy*, 51(4):608–613, 2009.

Parallelization of neutron transport calculations in Dragon5.1

Alain Hébert[1], Sigtryggur Hauksson * [1], and Daniele Tomatis[2]

[1]new*cleo, EDF Lab Paris-Saclay, Bd Gaspard Monge, 91120 Palaiseau, France*
[2]new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy*

January 23, 2026

– Internship proposal –
(ID No. 1011283)

***Keywords* —** Lattice calculation, DRAGON, GPUs, OpenMP
***Topics* —** Neutron transport, parallel computing, computer science

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Location EDF Lab Paris-Saclay, Bd Gaspard Monge, 91120 Palaiseau, or *new*cleo S.p.A., Via Galliano 27, 10129 Torino, Italy

Starting date Spring 2026

Duration 6 months

Context

*new*cleo is designing new Lead-cooled Fast Reactor (LFR) units for small modular reactors. These reactors sustain a fast neutron spectrum allowing for fission of heavier actinides, such as plutonium that is a by-product of light water reactors. Cooling is done by molten lead which shields photon radiation and has low neutron absorption.

The design and operation of reactors requires fast transport calculations that solve the Boltzmann equation for neutrons in the core of the reactor. Deterministic transport computer codes of choice are DRAGON5, which performs lattice calculations, and the full-core code DONJON [2, 1]. Both of these codes have been developed at Polytechnique Montréal, Québec, Canada, and are used at *new*cleo for LFR calculations. They are written in Fortran-2003. The goal of this internship is to speed up calculations with DRAGON5, focusing on calculations with the discrete ordinates (S_N method) or the method of characteristics (MOC) which both serve to solve the transport equation in multigroup approximation. This student will analyze the code, and suggest and implement improvements in parallelization implemented on multi-core processors, multiple processing units or graphical processing units.

*Contact person, sigtryggur.hauksson@newcleo.com

Description

In the first part of the internship, the student will analyze in detail the performance and the structure of the code to be sped up. This will either be the code implementing the S_N or the MOC method, both of which already have a parallelization in OpenMP. The analyzis of the code will be helped by presence of developers of Dragon in *new*cleo's team. The student will then, in consulation with the supervisors, propose which tools will be best adapted to improve performance. A non-exhaustive list of options are:

1. Improved use of OpenMP pragmas.
2. Distributed parallelism with MPI for calculation across multiple processing units.
3. Implementation on graphical processing units (GPUs) with CUDA or OpenACC.
4. Coarray processing following the Fortran2018 specification.

This choice will take into account calculational facilities at *new*cleo. In the second part of the internship, the student will develop the details of the calculation scheme proposed, testing different options to maximize speedup. Results of the internship will be written up in a final report.

Work plan

a) Analyzis of the structure of the relevant modules in Dragon.
b) Proposal for architecture to perform parallelization on.
c) Design of parallelized algorithm.
d) Implementation, testing of different options, measures of speedup.
e) Preparation of the final report.

Applicant profile

Master student in Computer Science.
Background: Experience with parallelization in scientific computing is preferable.
Required computer skills: Fortran, OpenMP, CUDA or OpenACC, LaTeX scientific editing (optional).

References

[1] Alain Hébert. DRAGON5 and DONJON5, the contribution of École Polytechnique de Montréal to the SALOME platform. *Annals of Nuclear Energy*, 87:12–20, 2016.

[2] G. Marleau, A. Hébert, and R. Roy. A user guide for DRAGON Version 5, 2025.