Contribution ID: **79**

Type: **Oral Presentation**

#4-79 COLIBRI Phase 2 –Experimental study of fuel rods vibration in 3D using the SAFFRON core mapping array in CROCUS

Friday, June 13, 2025 10:40 AM (20 minutes)

Since 2018, EPFL has been conducting an experimental program called COLIBRI, focusing on fuel rod displacement within the CROCUS reactor. This program allowed contributing to the European project CORTEX on noise analysis. Through three dedicated experimental campaigns COLIBRI has provided relevant validation data on fuel rod vibrations, which are a known source of power noise in pressurized water reactors (PWR), particularly in Siemens Konvoi and pre-Konvoi types. In some instances, these vibrations can lead to power fluctuations that require operational power reductions, and possibly increase in the risk of fuel deterioration.

In the framework of CORTEX and a doctoral thesis at EPFL, a novel type of miniature neutron detector, named MiMi, was developed. This scintillation-based detector enables real-time measurement of the thermal neutron flux via the lithium-6 reaction, with an active volume below 1 mm3 and a total volume in the millimeter range, using optical fibers for light collection. After the initial developments using analog acquisition electronics, the SiPM (silicon photomultiplier) signals were digitized via FPGA (field-programmable gate array) boards, allowing scalable neutron event counting.

For COLIBRI phase 2, this technology was expanded to create an array of up to 160 MiMi detectors, allowing for 3D mapping of the neutron flux within the CROCUS core. Named SAFFRON, this system is positioned interpin (between the rods), and is complemented with reference fission chambers located outside the core for these experiments. Together, these detectors enable detailed mapping of the modulation noise induced by fuel rod oscillations inside the core –an improvement over previous campaigns that were primarily limited to ex-core data and a smaller subset of in-core measurements. In addition, the use of the same reference setup enables easy comparison between datasets. Notably, the array intrinsic synchronization between MiMi detectors allows a better study of the impact on the phase. The phase is directly related to the non-point kinetics component of the noise, providing enhanced understanding of reactor kinetics.

In this contribution, we will present the experimental setup, the experiments carried out, and first key results compared to previous campaigns. This new dataset represents a major step forward in the modeling and mitigation of neutron noise in nuclear reactors, paving the way for future applications in monitoring and managing fuel vibrations in operational settings.

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Session Classification: #04 - Research Reactors and Particle Accelerators

Track Classification: 04 Research Reactors and Particle Accelerators