Importance of Research Reactors in Human Capacity Building in Nuclear Science and Engineering

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Research reactors, especially the ones located on university campuses, play a significant role in providing the needed education and training to students of nuclear science and engineering. Usually, the training is provided in the form of laboratory exercises that are offered as a standalone course or that may be incorporated in other coursework that is covered by the students during their studies. However, the overall mission of a university research reactor should be viewed to have a broader impact that also includes scientific research and community engagement and service, all of which may also be considered as important activities that are capable of providing an invaluable educational experience to students and trainees.

In the United States of America (USA), there are currently nearly 24 university reactors that operate in such capacity. These reactors vary widely in their characteristics (e.g., power, facilities etc.) and utilization levels. The history of these reactors was initiated at North Carolina State University (NCSU) in the late 1940s of the twentieth century. By 1953, the first university reactor in the world went critical on the NCSU campus. This reactor was awarded the R-1 license by the US Atomic Energy Commission and operated until 1955. Since 1972, the PULSTAR reactor has been operating on the NCSU campus. The PULSTAR is a 1-MWth (and is being upgraded to 2-MWth) open pool reactor that is light water moderator and cooled. It is fuelled with UO_2 fuel that is enriched to 4% in U-235. The fuel has the form of pellets contained within Zircalloy-2 cladding. It is arranged as a 5×5 array of pins in fuel assemblies. In addition, the PULSTAR core is reflected by beryllium and graphite reflectors, which serve to enhance the excess reactivity of the core. *FIG. 1.* below shows views of the core of the PULSTAR reactor and a typical fuel assembly.

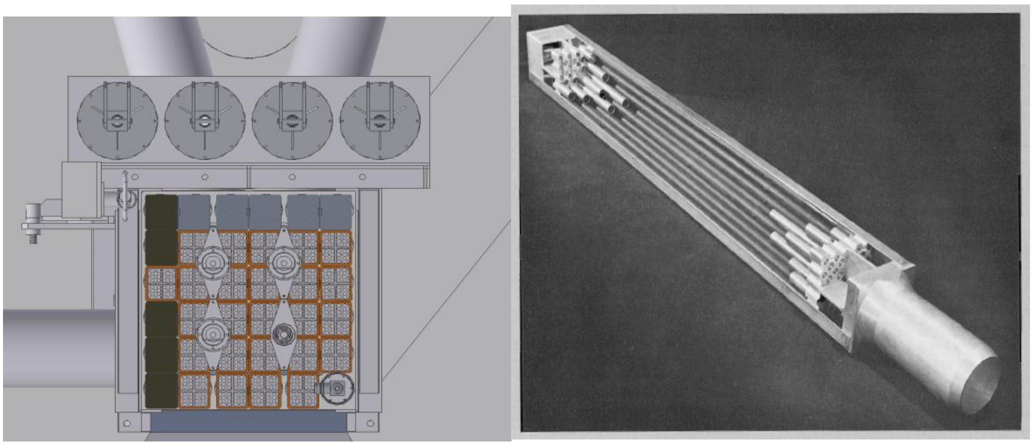

FIG. 1. A schematic of the core of the PULSTAR reactor (left) and a fuel assembly (right).

Based on its current mission and utilization objectives, the PULSTAR reactor serves as a good example for the assessment of the potential impact of university research reactors on human capacity building. Over the past ten years, the PULSTAR has been engaged in an ambitious plan to develop modern educational modalities and research instrumentation. Traditionally, the PULSTAR reactor was utilized in offering basic class work in nuclear reactor physics and radiation measurements to students on the NCSU campus. However, since 2004, the educational capabilities of the PULSTAR were extended, through the use of the internet, to cover students on the campuses of other universities inside and outside the USA. Inside the USA, classes were offered to students at the University of Tennessee and Georgia Institute of Technology. The same approach was recently implemented on an international scale and nuclear reactor physics experiments were conducted for students on the campus of the Jordan University of Science and Technology. In all cases, internet based audio-visual and data links are established between the remote site and the control room and operating console of the PULSTAR reactor. Data such as power, temperature and control rod positions are passed digitally between the two sites. Consequently, students at the remote site are able to observe, participate and analyse the experiments in a manner that is highly similar to that of on-campus students.

In scientific research, a comprehensive vision for the utilization of the PULSTAR reactor as a radiation source has been implements. Four facilities have been setup at PULSTAR including a unique intense positron beam and associated spectrometers, an ultracold neutron source, a powder neutron diffractometer and a neutron imaging facility (see *FIG. 2.*). The design and construction of these facilities involved strong engagement of undergraduate and graduate students of various disciplines including nuclear engineering and physics. Clearly, this provided strong training opportunities in science and engineering to the participating students and helped contribute to human capacity building in fields such as radiation science, non-destructive examination and fundamental physics. As a result of their engagement, many of the students have chosen to either join graduate study programs or to continue their careers at academic, research and industrial institutions.

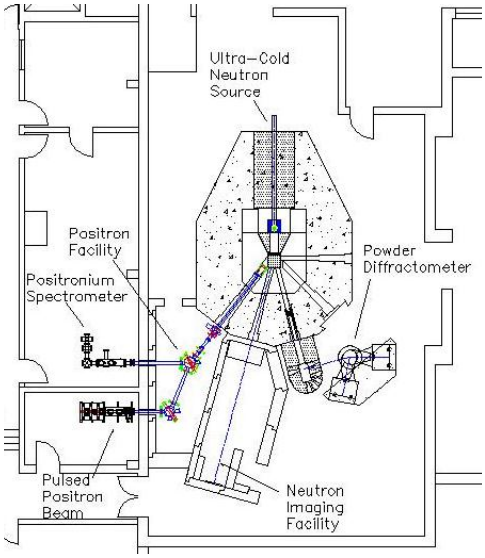

FIG. 2. A layout of the PULSTAR beam port floor showing the various research facilities and instruments.

Finally, as an important part of its mission the PULSTAR reactor provides its capabilities for use by industrial and governmental entities. In-core and ex-core irradiation facilities of the reactor have been utilized in support of medical, environmental and other applications. For example, a strong experience has been gained in supporting the testing needs of defence contractors in the USA. Often, activities related to such applications are being conducted simultaneously with other aspects that were mentioned above. This helps establish a strong practical perspective for the students that are operating within the PULSTAR reactor, which results in a unique educational experience for these students.