Neutron Science the Italian Way: State of the Art and Future Perspectives

Terms of Reference

Workshop Objective

This 1.5-day workshop will provide sufficient technical information and understanding about the current role and perspectives of the TAPIRO and TRIGA reactors in Italian and international neutron research. In particular, the outcome of the recent comparative studies on TAPIRO HEU-LEU conversion and other non-HEU alternative technologies using an international team of experts will be discussed. To this aim, the international panel of experts will:

- Summarize their assessment regarding the neutronic simulation outcomes of the comparative analysis between some selected applications performed with the actual HEU TAPIRO and a possible LEU solution. Provide a more general assessment regarding the non-HEU alternative technologies and capabilities to maintain or enhance the future perspectives of neutron science in Italy;
- Provide a synthesis document describing those outcomes.

Additionally, the workshop will lay the technical foundation to define the opportunities to collaborate towards HEU minimization in Italy.

Background

Italy takes part in intense experimental scientific activities in the Fission Neutron Science field. These activities are synergistically performed, for the most part, at three main Italian research reactors, one at the Laboratory of Applied Nuclear Energy (LENA) at the University of Pavia and two at ENEA Casaccia Research Center near Rome.

The LENA research reactor is a 250 kW TRIGA reactor, whereas the two research reactors at Casaccia Center include a 1MW TRIGA reactor and a zero-power fast neutron source reactor named R.S.V. TAPIRO.

TAPIRO is a compact fast facility driven by a highly enriched uranium-based fuel cylinder surrounded by a copper reflector and a biological shield. The system is crossed by several experimental channels. Currently TAPIRO is involved in experimental programs in collaboration with CEA, INL, CERN, F4E, CIEMAT, INFN, ESA/ASI. ENEA is also part of the NEA Nuclear Education, Skills and Technology (NEST) program framework.

The global research reactor community, through leadership by the U.S. Department of Energy's National Nuclear Security Administration (DOE/NNSA) and the IAEA, has focused on converting research and test reactors from the use of high enriched uranium (HEU) fuel to low enriched uranium (LEU) fuel and minimizing the use of HEU fuel in civilian applications for over 40 years.

U.S. DOE/NNSA's Office of Material Management and Minimization (M3) sponsored a cooperative feasibility study between Argonne National Laboratory (ANL) and ENEA to assess the feasibility of converting the TAPIRO research reactor from HEU fuel to LEU fuel.

Feasibility Study

ENEA and ANL began a joint study in 2014 to assess the technical feasibility of a conversion of TAPIRO reactor from HEU to LEU fuel. The results of this study were summarized in two joint documents issued by ENEA and ANL on February 3, 2016, and August 2, 2018.

The technical evaluation was guided by the following major constraints: 1) any designs requiring alteration to the TAPIRO biological shield (concrete structure) and core support flange would not be considered; 2) the control rods and irradiation channels locations must remain unchanged and; 3) the design must satisfy the safety requirements and result in minimal loss of performance for key performance metrics.

The primary conclusions of the first study are: 1) Although there are no major engineering or safety concerns identified for converting TAPIRO to the conceptual LEU design, the fission spectrum currently at the HEU core center (used as neutron reference field for different applications) is lost in the LEU design because the amount of U-238 present in LEU fuel; 2) in radial channel 1 the same integral amount of damage in silicon is achieved by the LEU design but the damage as function of distance from the core center is more degrading as compared to the HEU design and; 3) further investigations on shielding are needed.

ENEA and DOE/NNSA agreed to hold a technical workshop with an international panel of experts to better characterize the feasibility study challenges and fully explore the opportunity presented by TAPIRO. Due to the COVID pandemic, the workshop was implemented in a phased manner with multiple virtual meetings and culminated in a final in-person review held at the ENEA Casaccia Research Center in May 2022. The team of experts identified four key areas of neutron science research where the HEU fueled TAPIRO has demonstrated capability to support ongoing and planned research activities in the international scientific community. Consensus was also reached regarding the lack of quantitative information to evaluate the ability of an LEU converted TAPIRO, or application of another non-HEU technology, to meet the objectives of these key research areas.

Following the workshop, ENEA and ANL agreed to target two years to complete detailed simulation outputs for the HEU and LEU TAPIRO models for specific experiment exemplars and explore how the TRIGA RC1 at Casaccia and other TRIGA reactors illuminate opportunities for ENEA and Italy.

The technical experts are nearing completion of their analyses and a final ENEA – NNSA workshop is proposed in June 2025 to summarize their assessment and provide policymakers data-informed information to support decisions about the future path of non-HEU alternatives for Italian neutron science.

Participants

Participants in the technical workshop will include:

- ENEA and NNSA/M3 leadership.
- Technical experts from ENEA and ANL, as well as international experts who were selected to support the studies.
- Key stakeholders from the Italian government agencies