ANS HFICD

Fall 2022 Newsletter

http://hficd.ans.org

Fall is in the air! Here in Knoxville, TN the leaves are changing, the temperatures are dropping, and the heat is kicking on (which makes me extra thankful for low cost, reliable, nuclear power). For the ANS Human Factors, Instrumentation & Control Division (HFICD) this Fall, there is a ton of behind-the-scenes work going on as we prepare for the 2023 Nuclear Plant Instrumentation, Control, and Human-Machine Interface Technologies (NPIC-HMIT) conference that will be held in Knoxville next Summer. Panels are being put together, abstracts are being written, and plans are being made to make this NPIC & HMIT the best one yet! If you missed the “call for papers” announcement, we have attached a copy at the end of the newsletter, and you still have until November 18th to get your abstracts submitted. In other news, the Division is pleased to congratulate all of our 2022 award winners, with Dr. Imre and Maria Pázsit winning the Don Miller Award, Dr. Leo Fifield winning the H.M. Hashemian Mid-Career Award, and Dr. Dianne Bull Ezell winning the Ted Quinn Early-Career Award. These winners are all immensely qualified and have made significant contributions to our field.

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Additionally, this newsletter is highlighting a very interesting paper from this year’s Annual Meeting written by three individuals from the National Institute of Standards and Technology (NIST). In 2021 the NIST Center for Neutron Research National Bureau of Standards Reactor (NBSR) experienced a fuel failure during startup, and this paper describes the development of a Linear Nuclear Channel Noise Detection System that can help detect similar issues in the future. Special thanks to Anil Gurgen, Dagistan Sahin, and Osman Sahin Celikten for their work in this area.

The Young Member Spotlight continues in this issue with Jinding Xing, who is a Ph.D. student at Carnegie Mellon University. Please continue to encourage and look out for the many young members of our division who do valuable work in this field. I hope to see many of you at the ANS Winter Meeting in Phoenix here in just a few weeks, and I hope that you enjoy the newsletter! Thank you for being a part of HFICD!

- Adam Deatherage, MBA
AMS Corporation
Secretary & HFICD Communications Committee Chair

Don Miller Award

This award was established in 2009 by the ANS HFICD. It is named after Dr. Don W. Miller, Professor and distinguished Program Chair at the Ohio State University Nuclear Engineering Program, a prior member of the Advisory Committee on Reactor Safeguards, and past ANS President.

The award is given to an individual or team who has made recognized contributions to the advancement of one or both of the fields of nuclear instrumentation and control or human-machine interface through individual or combined activities that reflect the life and contributions of Dr. Miller.

Click here to submit a nomination for the Don Miller Award.

H.M. Hashemian Mid-Career Award

This award was established in 2018 by the ANS HFICD. It is named after Dr. H.M. Hashemian, President and CEO of Analysis and Measurement Services Corporation, recognized expert in nuclear instrumentation and controls, and avid proponent of the future generation of nuclear scientists and engineers. This award recognizes an individual for sustained outstanding contributions to nuclear instrumentation and control, human factors engineering, or human machine interface over the first 15-25 years of his or her career.

Click here to submit a nomination for the H.M. Hashemian Mid-Career Award.

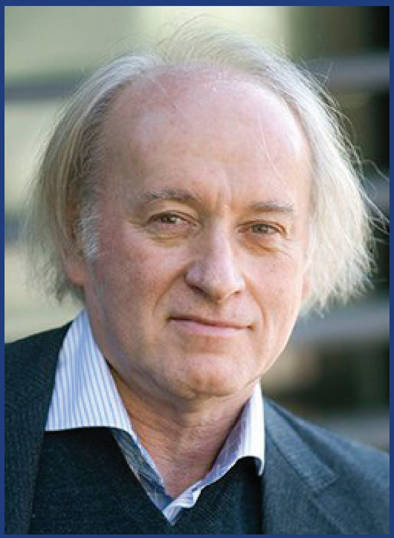
Ted Quinn Early-Career Award

This award was established in 2017 by the ANS HFICD. It is named after Mr. Ted Quinn, President of Technology Resources, recognized leader in I&C and former ANS President. This award highlights the importance of young members in the future developments of nuclear instrumentation and controls and human factors research, development, and deployment.

Click here to submit a nomination for the Ted Quinn Early-Career Award.

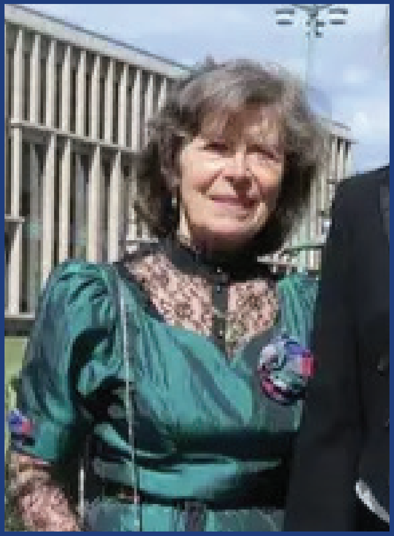
2022 Don Miller Award Winners

Don Miller Award - *Dr. and Mrs. Imre and Maria Pázsit*



Dr. and Mrs. Pázsit have been jointly awarded the Don Miller Award for their seminal contributions, both individually and in co-operation, to the advancement of noise analysis, reactor diagnostics, and instrumentation and control technologies. Dr. and Mrs. Pázsit started their careers in Hungary, at the Roland Eötvös Geophysical Institute (ELGI). Dr. Pázsit then went on to do a PhD in reactor noise analysis at the Central Research Institute for Physics (KFKI), whereas Mrs. Pázsit continued her work in ELGI. Dr. Pázsit's PhD work led to the elaboration of a method of identifying and locating excessively vibrating control rods in PWR cores. This is a very practical problem in VVER-type reactors, and the method became the first ever application of on-line monitoring for identifying such a faulty control rod in the Paks-2 reactor in Hungary in 1984.

The couple moved to Sweden in 1983 when Dr. Pázsit got an invitation as a visiting scientist in the reactor noise group of Studsvik Energiteknik AB in Nyköping. There he worked to develop a noise analysis system at the Swedish power plant Forsmark for early anomaly detection. At that time Mrs. Pázsit also began working in the Nuclear Division of Studsvik, working on the in-core fuel management (ICFM) system codes CASMO and SIMULATE. This group was the embryo of the internationally leading ICFM company Studsvik of America, and later Studsvik Scandpower.



In 1991, Dr. Pázsit got a state-endowed chair of Nuclear Engineering in Chalmers University of Technology in Göteborg, where he has served as a professor ever since. Most of his research has concerned power reactor diagnostics for anomaly detection, and the theory of zero power reactor noise for measurement of reactivity in subcritical systems. Both areas have a direct bearing on instrumentation and control of nuclear facilities. Partly, by elaborating new methods of diagnosing and quantifying anomalies and various disturbances and malfunctions based on physical models and innovative data analysis systems, including artificial intelligence and machine learning methods for control, and also giving rise to new ideas of instrumentation.

This research led to a collaboration with the power plant Ringhals to develop new surveillance and diagnostic methods. Dr. and Mrs. Pázsit founded a company, Nucleus DatorFysik, to commercialize this research which led to the company performing signal analysis and diagnostics based on periodic measurements at Ringhals. The company has gone on to perform analysis and evaluation of ex-core detector signals in PWRs for core-barrel motion diagnostics, as well as work for GSE Power Systems validating their software for BWR stability analysis in the Oskarshamn power plants.

ANS HFICD

2022 H.M. Hashemian and Ted Quinn Award Winners

H.M. Hashemian Mid-Career Award - *Dr. Leo Fifield*

Dr. Leo Fifield has been awarded the H.M. Hashemian Mid-Career Award for his impact within the field of nuclear materials instrumentation testing & control. Leo has investigated the effects of structure and stimuli on polymer material performance for more than 20 years, including as a scientist at PNNL since 2005. Over the past 10 years, the core of Dr. Fifield's research at PNNL has been motivated by a desire to understand, predict, control and improve material degradation of nuclear grade instrumentation cables within nuclear power plants. Leo has leveraged his background knowledge and expertise in the area of polymer materials to address critical concerns in this area. In doing so, he has led the DOE LWRS Materials Research Pathway Cable Aging and Cable NDE Tasks and is a key member of the DOE-EPRI-NRC Cable Research Coordination Team (CRCT) working group. He helps develop guidance standards for nuclear cables as an active member of the IEEE Insulated Conductors Committee. His research and dedication in this area have led to the development of extensive accelerated aging and testing capabilities and a one-of-a-kind cable/motor test bed at PNNL. The ARENA test bed is enabling development of online monitoring capabilities and understanding of complimentary NDE techniques to track aging in electrical components under simulated service conditions.

The contributions of Dr. Fifield to the field of nuclear cable reliability research have been marked by substantive collaborations with a range of stakeholders from other national labs to industry groups, licensees, service providers, suppliers, and universities. Through his work with ANS as well as IEEE, American Chemical Society, QNDE, and SPIE, Dr. Leo Fifield has demonstrated sustained outstanding contributions to nuclear instrumentation and control. Dozens of technical reports, conference proceedings, and journal articles document the advances he has led supporting advances in reliability, safety and effectiveness of cable systems and aging management programs in the nuclear power industry.

2022 H.M. Hashemian and Ted Quinn Award Winners

Ted Quinn Award - *Dr. N. Dianne Bull Ezell*

Dr. Bull Ezell has been awarded the Ted Quinn Early-Career Award for her leadership in developing nuclear instrumentation for advanced reactors and extreme environments. Dr. Bull Ezell is currently a group leader and a researcher at ORNL in simulation, building, and testing of electronics and instrumentation with a focus in advanced nuclear reactors and harsh environments. She is a nationally recognized engineer researcher and her work directly supports the Molten Salt Reactor (MSR) community with her unique expertise in molten salts chemistry, instrumentation, and control development in support of advanced MSR systems.

Dr. Bull Ezell is fostering scientific innovation by developing new capabilities and engaging successful research programs with different DOE offices. She is not only involved with the MSR program but also with the Nuclear Energy Advanced Modeling and Simulation program as well as the Advanced Sensors and Instrumentation Program where she is involved with cutting-edge science in the development of electronics and instrumentation in the harsh environment of advanced nuclear reactors. Dr. Bull Ezell is also an active member of ANS, where she has participated in numerous conference review and program committees, and she is also very committed to local community service organizations. She is particularly passionate about engaging young women in STEM and the energy she brings to discussing nuclear energy and the technical challenges of rad-hard electronics and instrumentation make her an excellent ambassador for the field of nuclear instrumentation and control.

Young Member Spotlight - Jinding Xing

My name is Jinding Xing. I'm originally from China and I'm currently a fourth-year Ph.D. student at Carnegie Mellon University. I have a Bachelor of Quantity Surveying and a Master of Construction Project Management. My Ph.D. research uses techniques such as Human Reliability Analysis, Digital Twin, Augmented Reality, and Machine Learning to improve human performance in operating the Nuclear Power Plant (NPP).

What initially interested you in the Nuclear Industry?

I was initially exposed to the Nuclear Industry through my Ph.D. project. This project is funded by the Department of Energy and aims to develop context-aware augmented reality glasses for nuclear field workers. While working on the project, I realized it's much more complex and challenging to ensure operational safety and productivity in an NPP compared with other civil infrastructures. From there, I have become increasingly interested in the Nuclear Industry.

What is something interesting everyone in HFICD should know about you?

I'm a very passionate person, a plant lover, and an outdoor person. I love jogging around my neighborhood.

What's your biggest goal for the next 5 years?

My biggest goal for the next 5 years is to graduate with my doctoral degree, then pursue a career in universities or national labs to continue my research.

Development of Linear Nuclear Channel Noise Detection System

Anil Gurgen,[1,2], Osman Sahin Celikten,[1] and Dagistan Sahin,[1]

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INTRODUCTION

The NIST Center for Neutron Research (NCNR) National Bureau of Standards Reactor (NBSR) is a 20 MW, heavy water cooled and moderated tank-type research reactor operational since 1967. The NBSR has been a vital neutron source for the scientific community since then.

On February 3, 2021, the NBSR experienced a fuel failure during startup. Post-incident video inspection showed that one fuel element had lifted from its position indicating the fuel element was unlatched. The fuel element was found dislocated from lower grid plate and sitting sideways. Hence, coolant entry was substantially blocked for the fuel element. Subsequent analysis of the nuclear channels (NCs) revealed that the power oscillations at these channels were of greater amplitude compared to previous startup NC oscillations. Nuclear analyses predict that power oscillations during the event may be predominantly caused by partial coolant voiding due to limited coolant flow within the fuel element coolant channels [1]

It is part of the operating procedure to operate the reactor around 10 MW at startup to visually check for power oscillations on reactor power indicating digital trend recorders. This step was modified in the late 1990s after 5% to 7% oscillations were observed in nuclear instrument channels in a preceding unlatched fuel element incident[1][2]. During the February 3, 2021 incident, despite the power oscillation amplitude being higher compared to previous cycle data, the visual indications were not significant to alert operators at the 10 MW check. Therefore; a digital noise detection system is proposed to aid operators to detect potential coolant voiding or fuel element movements during startup to notice any unlatched fuel element. Such a system would track NC measurements and alarm if oscillations in the measurements exceed statistically significant levels compared to nominal values. The aim of this work is to describe a noise calculation method for the design of such noise detection system. For this purpose, a statistical method is used to analyze past startup and full power operation data of the NBSR to quantify reactor power noise characteristics.

METHODOLOGY

The NBSR has five separate nuclear instrument channels (NC-3 to NC-7) to monitor the reactor power level ranging from subcritical state at startup through the full power. Each channel consists of a detector to measure the leakage neutron flux from the core. These channels monitor the reactor power in a continuous manner and digital recorders display a trend and store this information. The noise detection system works with the recorder continuously to measure power oscillations; which is defined as reactor power noise in this work. Apart from the noise due to electrical components involved in the NCs, the noise detection system aims to detect noise caused by the neutron disturbances in the reactor. An example of such a disturbance might be the partial coolant voiding due to departure from nucleate boiling[3]. Since the noise detection system aims to catch increased reactor power noise due to presence of additional physical phenomena, any uncertainties related to detecting, counting or electrical network are expected to be similar for normal and abnormal conditions.

While at steady state operation, reactor power noise is the difference between the measured power and the actual power of the reactor. The actual value of the instantaneous reactor power is not known precisely. However, if it's assumed that the reactor power noise has a distribution with zero mean, the average value of the measured power can represent the actual power of the reactor. In this case, reactor power noise can be calculated by the difference between instantaneous value and average value of the measured power of the reactor, given by Eq. (1) where $P_n{}'$ is the reactor power noise, P_n is the instantaneous measured power and $\overline{P_n}$ is the average value of measured power. The reactor power noise distribution can be approximated by calculating the difference at each measurement point over the considered time interval to verify the initial assumption.

$$P_n{}' = P_n - \overline{P_n} \qquad (1)$$

If the reactor power noise is normally distributed with zero mean (μ), standard deviation (σ) of the distribution can represent the magnitude of the noise. A useful concept to measure the noise is signal-to-noise ratio (SNR) which can be approximated by the ratio of squared mean to variance of the measurements. The measurements can be normalized to have a mean value of one. For normalized measurements, the SNR in decibels (dB) and can be calculated by Eq. (2). As the SNR approaches to 0 dB, the magnitude of noise in the signal approaches to the magnitude of the signal; therefore, lower SNR represents higher noise in the measurements.

$$SNR = 20log\left(\frac{1}{\sigma}\right) \qquad (2)$$

The noise detection system continuously works with the reactor; therefore, the SNR calculation needs to be performed using streaming data. During the operation of the reactor, unintentional trends in the reactor power are inevitable and these trends need to be considered while averaging the measured power. A moving average scheme is applied to average the measured power. For a measurement n, the moving average of reactor power with a window size W is given in Eq. (3).

$$\overline{P_n} = \frac{1}{W}\sum_{i=n-W}^{n} P_i \qquad (3)$$

Similarly, σ needs to be calculated incrementally on a streaming data as the noise detection system continuously works with the reactor. Reactor power noise population increases with more operational data; therefore, σ needs to be updated every time there is a new measurement. For a measurement n, σ can be calculated using Welford's method given in Eq (4) [4]. Calculated σ_n is plugged in to Eq. (2) to continuously calculate and update the SNR.

$$\sigma_n = \sqrt{\frac{(n-2)\sigma_{n-1}^2 + (P_n - \overline{P_n})(P_n - \overline{P_{n-1}})}{n-1}} \tag{4}$$

RESULTS AND ANALYSIS

In order to test the noise calculation method, operational data of the NBSR prior to February 3 incident are used. The February 3 incident happened on Cycle 654, and the previous four cycles are used to calculate the nominal noise. To test the assumption that the reactor power noise has a normal distribution with zero mean, full power (20 MW) operation data of Cycles 650-653 are analyzed

The analysis of Cycle 652 is given as example. Cycle 652 NC data was recorded approximately every 10 seconds, and 120000 measurement points from the full power are used for analysis. The reactor power noise is calculated incrementally with moving average with a window size of 10. For NC-3, the magnitude and density distribution of noise are given in Figure 1. After the calculations are completed for all 120000 measurement points, final values of μ, σ and SNR are calculated and given in Figure 1. In this figure, a normal distribution

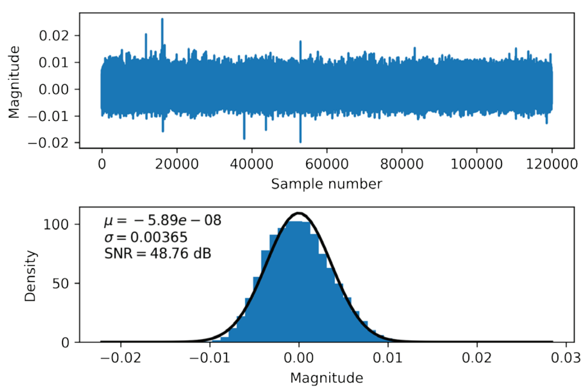

Fig. 1. Cycle 652 full power noise distribution

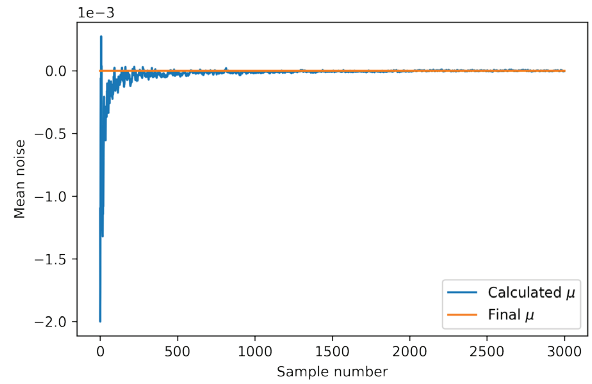

Fig. 2. Convergence of mean noise at Cycle 652 at full power

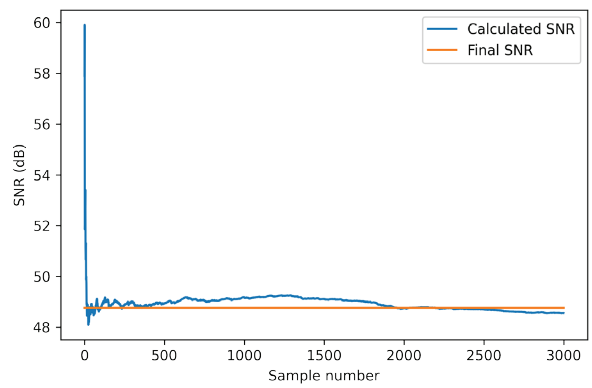

Fig. 3. Convergence of SNR at Cycle 652 at full power

is plotted with the calculated μ and σ. Therefore, it can be concluded that the reactor power noise converges to normal distribution and the initial assumption of SNR calculation is valid. Convergence of μ and SNR for Cycle 652 are given for the first 3000 measurement points in Figure 2 and Figure 3 respectively. The figures show that mean noise and SNR quickly converge to their final values, hence bring confidence to the final SNR calculation.

Analyses on other cycles show similar results and the results are not repeated here. Calculated SNR values at full power are given in Table I. It must be noted here that Cycle 651 and Cycle 653 needed to be divided due to operational deviations; therefore, represented with two columns in Table I and Table II. After Cycle 653, regulating rod system is upgraded[5]. Regulating rod system maintains the reactor

TABLE I. SNR values of nuclear channels at full power

	Cycle 650	Cycle 651_1	Cycle 651_2	Cycle 652	Cycle 653_1	Cycle 653_2
NC-3	48.58	48.64	48.28	48.76	51.95	52.92
NC-4	48.21	48.38	48.09	48.51	51.77	52.55
NC-5	48.07	48.19	48.04	48.34	51.44	52.51
NC-6	48.32	48.49	48.19	48.60	52.00	52.88
NC-7	48.21	48.36	48.16	48.49	51.80	52.85

TABLE II. SNR values of nuclear channels at startup

	Cycle 650	Cycle 651_1	Cycle 651_2	Cycle 652	Cycle 653_1	Cycle 653_2	Cycle 654
NC-3	47.47	42.65	31.06	50.78	50.50	46.49	37.98
NC-4	47.14	42.10	30.86	49.86	51.96	46.36	36.63
NC-5	46.36	42.68	30.80	49.79	51.06	46.26	35.97
NC-6	46.75	42.48	30.83	50.45	51.65	46.16	36.54
NC-7	47.40	42.58	30.83	50.21	51.55	46.04	36.35

power, and the upgraded system decreased the reactor power noise.

Noise detection system is proposed for startup, and the NBSR is operated at 10 MW during the startup to check power oscillations. Therefore, it is required to analyze SNR calculation at startup data of the NBSR. With the current operating procedure and data collection system, there is not enough measurement points at startup to get a clear noise distribution. The total number of measurement points range between 40-320 for cycle startups. Cycle 653_1 is selected for analysis because it has the most measurement points. For NC-3, the magnitude and density distribution of noise for this cycle are given in Figure 4. The reactor power noise distribution is not yet converged to a complete normal distribution, but still can be represented with a normal distribution as μ approximated to zero. Convergence of SNR for Cycle 653_1 is given in Figure 5. Despite the measurement points are scarce for startup, analysis of Cycle 653_1 provides evidences that the reactor power noise also has a normal distribution with zero mean at startup.

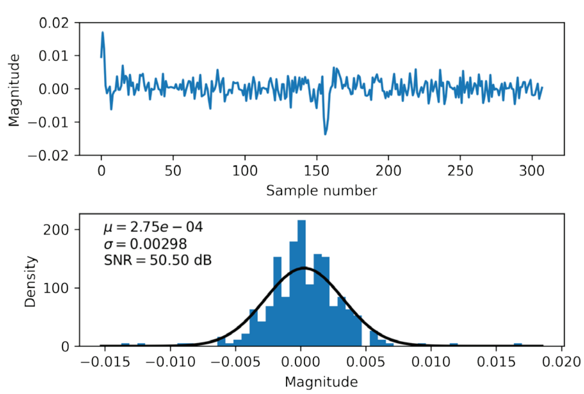

Fig. 4. Cycle 652 full power noise distribution

Calculated SNR values for startup are given in Table II. Cycle 654 has a lower SNR, indicating that the reactor power noise is higher in this startup compared to other cycles. Calculated final σ of the reactor power noise is four times greater in Cycle 654 compared to previous cycles. Cycle 651_2 also has a low SNR, but the reason for low SNR within the Cycle 651_2 is due to an immediate reduction in reactor power followed by a quick recovery. The averaging of the transient added artificial noise and caused a lower SNR compared to the other cycles.

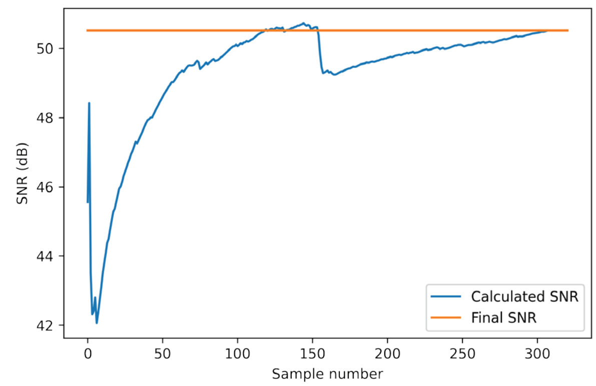

Fig. 5. Convergence of SNR at Cycle 652 at full power

CONCLUSIONS AND FUTURE WORK

In this study, a noise calculation method is demonstrated on nuclear channel measurements of the NBSR. This method is based on averaging the nuclear channel measurements to estimate reactor power noise distribution, then to calculate signal-to-noise ratio (SNR) using the distribution. While calculating the SNR, the reactor power noise is assumed to be normally distributed with zero mean. This assumption is validated for full power data. And analysis of Cycle 653_1 showed that this assumption is also valid for startup data. The method presented in this work can quantify increased reactor power noise caused by partial coolant voiding during the February 3 incident.

The future work will focus on to design noise detection system using the SNR based noise calculation. Corrective actions and cleaning efforts of the NBSR are still under implementation, and the noise detection system will be developed and installed before the restart of the NBSR.

ACKNOWLEDGMENTS

Special thanks to the NBSR Reactor Operations and Engineering personnel for support and valuable feedback during the development of this project.

DISCLAIMER

Certain commercial equipment, instruments, or materials are identified in this study in order to specify the experimental procedure adequately. Such identification is not intended to imply recommendation or endorsement by the National Institute of Standards and Technology, nor is it intended to imply that the materials or equipment identified are necessarily the best available for the purpose.

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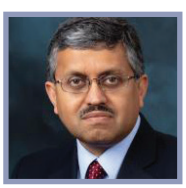

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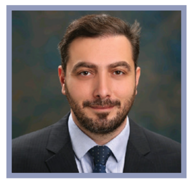

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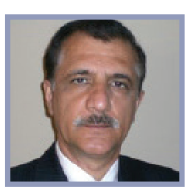

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Upcoming ANS Meetings

2022 ANS Winter Meeting and Technology Expo
November 13-17, 2022
Phoenix, Arizona
Arizona Grand Resort

2023 ANS Annual Meeting
June 11-14, 2023
Indianapolis, IN
Marriott Indianapolis Downtown

2023 13th NPIC & HMIT & PSA
July 15-21, 2023
Knoxville, TN
Knoxville Convention Center

2023 ANS Winter Meeting and Technology Expo
November 5-8, 2023
Washington, D.C.
Washington Hilton

NPIC&HMIT 2023

13th Nuclear Plant Instrumentation, Control & Human-Machine Interface Technologies

July 15–21, 2023 | Knoxville, Tennessee, USA | Knoxville Convention Center

Co-located with PSA 2023 ans.org/meetings/npic13psa2023/

CALL FOR PAPERS

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Lou Martinez, Kairos Power

PUBLICATION DEADLINES

NOVEMBER	ABSTRACTS SUBMISSION: **Friday, November 18, 2022**
DECEMBER	ABSTRACT REVIEW NOTIFICATION: **Monday, December 19, 2022**
MARCH	FULL PAPERS SUBMISSION: **Tuesday, March 07, 2023**
APRIL	FULL PAPER REVIEW ACCEPTANCE NOTIFICATION: **Monday, April 10, 2023**
MAY	FINAL CAMERA-READY PAPERS SUBMISSION: **Monday, May 1, 2023**

ABOUT THE MEETING

This topical meeting is the 13th in a series organized by ANS's Human Factors, Instrumentation & Controls Division (HFICD). Authors are invited to participate in the International Topical Meeting on Nuclear Plant Instrumentation, Control, and Human-Machine Interface Technologies (NPIC & HMIT 2023).

Sponsored by the American Nuclear Society (ANS), NPIC & HMIT is the de facto forum for nuclear instrumentation and control and human factors engineering professionals to meet with leaders in industry and academia, discover the state of the technology, exchange information, and discuss future directions.

The meeting welcomes the submission of full-length technical papers, which will be peer reviewed and published as conference proceedings. Accepted papers must be presented at the meeting to be included in the conference proceedings. Papers will be scheduled for either podium or poster presentation at the discretion of the meeting organizers. Detailed information and announcements regarding the conference will be posted on ans.org/meetings/npichmit13/

ABSTRACT GUIDELINES

Maximum of one page identifying title, authors, affiliations, and three paragraphs (total fewer than 500 words) describing the key concepts of the paper. A wide range of topic areas are highlighted on the second page of this call for papers. Authors are encouraged to submit papers on these proposed topics as well as others. The abstract template is on the **NPIC&HMIT 2023 Resources page**.

FULL PAPER SUBMISSION

Authors of accepted abstracts will be invited to submit full papers. Full papers must describe work that is new, significant, and relevant to the meeting. The limit for full-paper submissions is 10 pages. For papers exceeding 10 pages, page charges are $100/page for p. 11 and above. Authors of accepted papers must agree to register and attend the conference and present their papers. Papers that are not presented in person at the conference will not appear in the final conference publication.

SUBMIT AN ABSTRACT

epsr.ans.org/meeting/?m=364

PROGRAM SPECIALIST

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NPIC&HMIT 2023

13th Nuclear Plant Instrumentation, Control & Human-Machine Interface Technologies

July 15–21, 2023 | Knoxville, Tennessee, USA | Knoxville Convention Center

Co-located with PSA 2023 ans.org/meetings/npic13psa2023/

SUGGESTED TOPICS

IC. INSTRUMENTATION AND CONTROLS (I&C)

- IC1: Advanced I&C for Fuel Cycles
- IC2: Advanced Sensor Technology
- IC3: Advanced Surveillance, Diagnostics, and Prognostics
- IC4: Autonomous Control and Operation
- IC5: Cyber-Informed Engineering for Nuclear I&C
- IC6: Cybersecurity of I&C Systems
- IC7: Cybersecurity in Wireless Technologies, Digital I&C, and Digital Twins
- IC8: Data Analytics, Machine Learning, and Artificial Intelligence
- IC9: Digital Control System Applications
- IC10: Digital Twins and their Applications
- IC11: Digital System Reliability
- IC12: Diversity and Defense in Depth
- IC13: Education and Training of I&C Professionals
- IC14: Electromagnetic Compatibility (EMC) and EMI/RFI Issues
- IC15: Field Programmable Gate Arrays
- IC16: General Sessions in I&C
- IC17: Hazard and Failure Mode Analysis in Digital Systems
- IC18: I&C for Advanced Reactors
- IC19: I&C for Flexible Plant Operations
- IC20: I&C for Mobile Reactor Technologies
- IC21: I&C for Decommissioning of Reactor Technologies
- IC22: I&C Modernization
- IC23: I&C Regulations, Standards, and Guidelines
- IC24: Integrated Energy Systems
- IC25: Managing and Preserving I&C Knowledge and Competence
- IC26: Modeling Digital I&C Systems in PRA/PSA
- IC27: Next Generation I&C
- IC28: Nuclear Data Digitalization, Architecture, and Infrastructure Requirements
- IC29: On-line Monitoring for Maintenance Optimization
- IC30: Robotics in Nuclear
- IC31: Research Reactor I&C
- IC32: Safety Critical Software
- IC33: Sensor and Instrumentation for Physical Security of Nuclear Reactor
- IC34: Structural Health Monitoring
- IC35: Uncertainty Quantification of Artificial Intelligence and Machine Learning
- IC36: Uncertainty Propagation in Digital Twins
- IC37: Validation & Verification of Artificial Intelligence and Machine Learning
- IC38: Validation & Verification of Digital Twins
- IC39: Wireless Technologies for Nuclear Facilities

HF. HUMAN FACTORS (HF)

- HF1: Advances in Human Factors Engineering (HFE) Design and Analysis Tools and Methods
- HF2: Advanced Visualization
- HF3: Alarm Systems
- HF4: Application of Virtual and Augmented Realities to Nuclear Power Plants
- HF5: Cognitive Systems Engineering
- HF6: Computerized Procedures and Digital Instructions
- HF7: Concepts of Operation for Advanced and Small Modular Reactors
- HF8: Control Room Modernization
- HF9: General Sessions in Human Factors
- HF10: HF in Cybersecurity
- HF11: HF in Communications
- HF12: HF in Operation and Maintenance (O&M)
- HF13: HF in Training and Education
- HF14: HFE in Advanced Control Rooms
- HF15: HFE in Advanced and Small Modular Reactors
- HF16: HFE for Configuration Management
- HF17: HFE Standards and Guidelines
- HF18: HFE Verification and Validation
- HF19: Human-Automation Interaction
- HF20: Human Performance Evaluation and Monitoring
- HF21: Human Reliability Analysis
- HF22: Human-System Interface Design
- HF23: Operator Aids and Support Systems
- HF24: Operation of Hybrid Control Rooms
- HF25: Operating Experience
- HF26: Soft Controls
- HF27: Staffing and Qualification of Personnel
- HF28: Task Analysis and Function Allocation
- HF29: Use of Simulation for Human Factors Engineering
- HF30: Workstation and Workplace Design

NOTE: The topics listed above are not the final session titles; they are provided just as a guide. The NPIC&HMIT 2023 Technical Program Committee will be happy to expand the areas and include new sessions into the program. Please contact the Technical Program Chair vivek.agarwal@inl.gov to discuss new and alternative concepts.