

Computational dose assessment of a subcritical assembly driven by a deuterium-deuterium portable neutron generator

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ABSTRACT

This study presents the computational dose assessment of a subcritical assembly driven by a deuterium-deuterium portable neutron generator (PNG). The work was carried out to provide an evaluation of the neutron and photon dose distribution for a proposed PNG-driven reactor configuration and to assess the adequacy of shielding under both routine and abnormal conditions. Monte Carlo simulations were performed using MCNP5 version 1.6 for a model based on the PNG-driven Philippine Research Reactor – 1 Subcritical Assembly for Training, Education, and Research. Two scenarios were considered: normal operation and a loss of shielding. Ambient dose distributions were assessed using mesh tallies in the xy and the xz planes, together with dose estimates from six air-filled detectors placed at selected locations around the assembly. Under normal operation, the highest total dose rate was obtained at detector 103, which is closest to the PNG, with a value of 1.20×10^1 $\mu\text{Sv/hr}$, while the other detector locations were substantially lower. Assuming a total neutron generator operating time of 500 hours, continuous occupancy at detector 103 would correspond to an accumulated dose of about 6.0 mSv, which remains below the occupational dose limit of 20 mSv per year averaged over five consecutive years. Under the loss of shielding scenario, dose rates increased substantially across all detector locations, with detector 103 reaching 2.05×10^3 $\mu\text{Sv/hr}$. The radiation field also changed from being secondary photon dominated to neutron dominated, demonstrating the importance of water as a moderating and shielding material. Since loss of shielding represents an emergency scenario, the results were interpreted in terms of response time and exposure management. At the highest dose rate location, a response window of 2 to 4 hours would correspond to a potential exposure of approximately 4.1 to 8.2 mSv. The results show that the water shielding provides

sufficient dose reduction under the conservative exposure assumption for normal operation, while complete water loss would require immediate access restriction, rapid system shutdown, and optimized personnel deployment to minimize exposure. The study provides an initial computational basis for radiation safety, shielding assessment, and emergency planning for portable neutron generator operation in subcritical assemblies.

INTRODUCTION

Subcritical reactors are reactor systems in which the core does not sustain a fission reaction by itself and requires an external neutron source (ENS) to maintain neutron population during operation. These systems do not reach criticality and are useful for training, reactor physics experiments, neutron irradiation, and research activities where a controlled neutron field is required. The Philippine Research Reactor – 1 Subcritical Assembly for Training, Education, and Research (PRR-1 SATER) (Asuncion-Astronomo et al. 2019) is a subcritical reactor that primarily operates using a 5 Ci $^{241}\text{AmBe}$ external neutron source (ENS), with a neutron yield of 1.0×10^7 n/s, to start up the reactor (Asuncion-Astronomo et al. 2026). With the $^{241}\text{AmBe}$ ENS, researchers and operators can perform introductory demonstrations and research in reactor and neutron physics, including neutron spectrometry, detector testing, dose evaluation, and neutron irradiation. To expand the capability of PRR-1 SATER and extend the facility's utilization, a 2.48 MeV deuterium-deuterium (D-D) portable neutron generator (PNG) with a neutron yield of 1.0×10^8 n/s will be used as an alternative ENS.

The D-D PNG will provide the reactor a higher neutron yield compared to the $^{241}\text{AmBe}$ ENS. The D-D PNG generates neutrons through a fusion reaction in which ionized deuterium gas is accelerated through a potential difference to collide with a deuterated target (Geng et al. 2026), as shown in equation 1.

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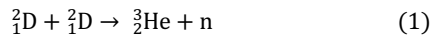
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KEYWORDS

deuterium-deuterium neutron generator, MCNP5, neutron dose, photon dose, radiation protection, subcritical assembly



Another difference between the D-D PNG and the ${}^{241}\text{AmBe}$ ENS is the energy distribution of neutrons that will initiate fission reaction in the reactor. The D-D PNG produces monoenergetic 2.48 MeV neutrons, whereas the ${}^{241}\text{AmBe}$ ENS provides a spectrum of neutron energies as shown in Figure 1. These differences in neutron spectrum and source strength are expected to change the neutron flux profile, facility utilization, and the radiation dose around the

reactor. Before integrating the D-D PNG into the PRR-1 SATER, a preliminary dose assessment should be performed to ensure the safety of the operators and researchers working in and around the reactor during operation and conduct of experiments. In addition to normal operating conditions, potential accident scenarios, such as loss of shielding (LOS), should also be evaluated to generate estimated radiological data necessary for emergency preparedness and response planning.

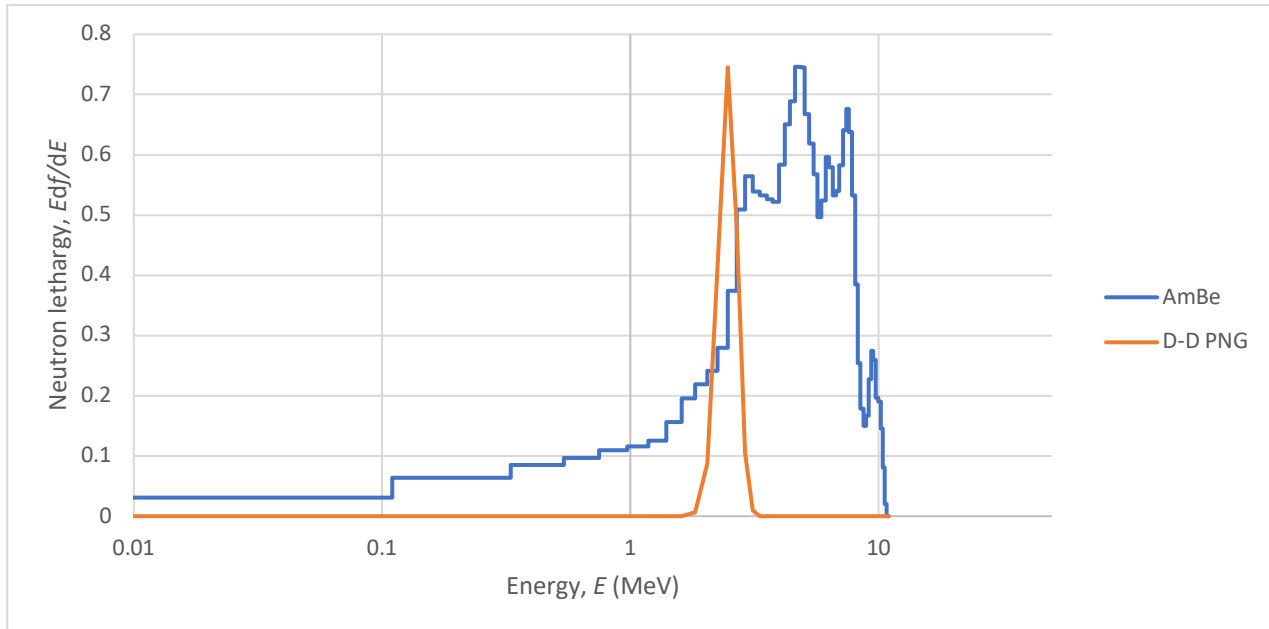
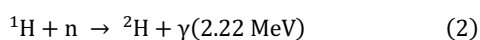


Figure 1: AmBe vs D-D PNG Spectrum

Because the PRR-1 SATER primarily functions as a neutron source, the preliminary dose assessment includes the doses from the neutrons produced by the D-D PNG and the neutrons from fission of nuclear fuel in the reactor core. In addition to the neutron dose, it is important to consider the contribution of the secondary photons that are being produced predominantly from the radiative capture interactions by the hydrogen content of the surrounding water and air in the system. This reaction, shown in equation 2, produces 2.22 MeV photons that can exit the tank and contribute to the radiation dose received by operators and researchers.



In this study, computational radiation transport methods were used to provide an initial dose assessment of the PRR-1 SATER when using the D-D PNG as an ENS. Monte Carlo N-Particle (MCNP5 v1.6) (Brown et al. 2010) was used, together with ENDF B VII.1 nuclear data (Chadwick et al. 2011), to model the accelerator-driven PRR-1 SATER and calculate both neutron and secondary photon dose during normal operation and loss of shielding scenario. These calculations and assessments provide important inputs to evaluate the adequacy of the facility's existing shielding design and to determine whether the current emergency plan remains sufficient to support the planned modification of the upgraded facility to operate in a PNG-driven mode. Such evaluations are essential for maintaining a comprehensive radiation protection program for the PRR-1 SATER facility.

MATERIALS AND METHODS

Deuterium-Deuterium (D-D) Portable Neutron Generator (PNG)

The PNG, shown in Figure 2, is an nGen-400 model that has been procured for the PRR-1 facility. The unit is equipped with a liquid-

cooled snout measuring 140 mm in length and 25 mm in diameter, from which a neutron beam with an approximately 5 mm spot size is emitted at the distal end. The generator head is made of aluminum for structural parts, copper for cooling, and kovar (Iron, Nickel, Cobalt) for high voltage insulation and vacuum integrity; these compositions can be seen in Table 1. The PNG can be configured for either D-D or Deuterium-Tritium (D-T) neutron production, but the model simulated in this study is the D-D configuration (Starfire Industries 2024; Starfire Industries 2025).

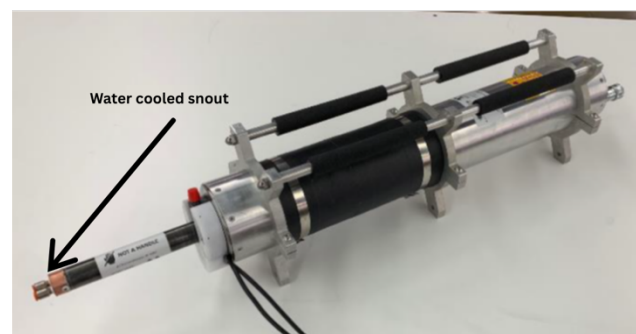


Figure 2: nGen-400 series D-D Portable Neutron Generator

Subcritical Assembly Model

The subcritical assembly considered in this study is based on the Philippine Research Reactor-1 Subcritical Assembly for Training, Education, and Research (PRR-1 SATER). PRR-1 SATER is a TRIGA fueled subcritical reactor assembly used for training, education, and research activities in reactor and neutron physics. The assembly is typically operated using a 5 Ci ${}^{241}\text{AmBe}$ external neutron source, which provides the neutron population needed to operate the system in subcritical mode. The reactor assembly consists of a TRIGA fuel rod lattice positioned inside a stainless-

steel water tank, where the surrounding water serves as the primary moderator and shielding.

In the model, the PRR-1 SATER core is represented by 44 fuel rods configured based on the SATER lattice geometry. The support structure of the core was included and no control rods were used. The core was placed inside a cylindrical stainless steel water tank. The water region had a radius of approximately 99.68 cm and extended vertically from the bottom to a height of about 350 cm, while the outer stainless-steel tank had a radius of 100 cm and a height of about 400 cm. The water region was modeled around the fuel, source, and core support structures.

For the accelerator-driven configuration in the model, the ²⁴¹AmBe source was replaced in the model by the D-D PNG. As shown in Figure 3, the PNG was positioned along the inside of the reactor tank, with the snout placed at the height corresponding to the geometric center of the reactor core. To estimate local dose at selected positions around the reactor, six spherical air-filled phantoms/detectors with a diameter of 30 cm were placed around the assembly. Four detectors, labelled 101, 102, 103, and 104, were located at the same elevation as the source and core mid region. Two detectors, labelled 105 and 106, were located above the tank. These positions were selected because they represent accessible areas near the assembly where operators may be present during operation or experiments.

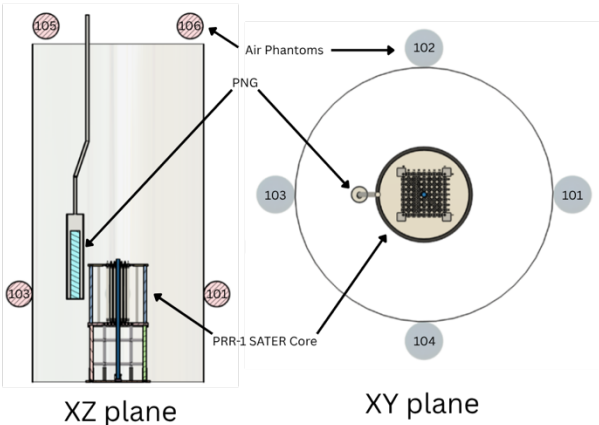


Figure 3: PRR-1 SATER core illustration with the portable neutron generator (PNG).

MCNP5 Simulation

Radiation transport calculations were performed using MCNP5 version 1.6 to evaluate the neutron and photon dose distributions of the model. The model used the ENDF/B-VII.1 nuclear data library for the materials declared seen in Table 1 and the corresponding thermal scattering S (α , β) data of water, zirconium, hydrogen, and graphite (Chadwick et al. 2011). The simulation was run with 5×10^8 particle histories to provide good statistics for the Monte Carlo calculations. The code was used to simulate particle transport through the source, assembly, shielding, moderating materials, and surrounding air regions.

Dose evaluation was carried out using point tallies and mesh tallies. Point dose evaluation was done at the six air-filled phantoms/detectors using separate photon and neutron tallies. Mesh tallies were defined to evaluate ambient dose distributions in the xy plane at $z = 34$ cm and xz plane at $y = 0$ cm. Neutron and photon fluxes were converted to ambient dose using ICRP-74 (ICRP 1996) conversion factors.

Table 1: Material compositions declared in the MCNP model of the PNG-Driven SATER

Component	Material	Density (g/cm ³)	Composition
Fuel Rod	Zirconium	6.506	Zr – 100% (⁹⁰ Zr – 51.45%; ⁹¹ Zr – 11.22%; ⁹² Zr – 17.15%; ⁹⁴ Zr – 17.38%; ⁹⁶ Zr – 2.8%)
	TRIGA fuel	6.365915	Er – 0.45% (¹⁶² Er – 0.00063%; ¹⁶⁴ Er – 0.0072%; ¹⁶⁶ Er – 0.1508%; ¹⁶⁷ Er – 0.1029%; ¹⁶⁸ Er – 0.1214%; ¹⁷⁰ Er – 0.0671%); H – 1.382% (¹ H – 1.382%; ² H – 0.00016%); Zr – 78.168% (⁹⁰ Zr – 40.217%; ⁹¹ Zr – 8.77%; ⁹² Zr – 13.406%; ⁹⁴ Zr – 13.586%; ⁹⁶ Zr – 2.189%); U – 20% (²³⁵ U – 3.946%; ²³⁸ U – 16.054%)
	Molybdenum	10.22	Mo – 100% (⁹² Mo – 14.84%; ⁹⁴ Mo – 9.25%; ⁹⁵ Mo – 15.92%; ⁹⁶ Mo – 16.68%; ⁹⁷ Mo – 9.55%; ⁹⁸ Mo – 24.13%; ¹⁰⁰ Mo – 9.63%)
	Graphite	1.70	C – 100%
	Incoloy-800	7.94	Cr – 21%; Fe – 43.563%; Ni – 32.5%; Si – 0.65%; Ti – 0.375%; Al – 0.375%; Mn – 0.975%; C – 0.065%; Cu – 0.488%
	Inconel-600	8.47	Cr – 15.5%; Fe – 8%; Ni – 75.093%; Si – 0.325%; C – 0.098%; Cu – 0.325%; S – 0.01%; Mn – 0.65%
Core Structural Component	Helium	1.660E-04	He – 100%
	Al-6061	2.70	Al – 97.2%; Mn – 0.088%
Detector	B-10 Enriched Boron	2.20378	B – 100% (¹⁰ B – 96%; ¹¹ B – 4%)
Surrounding regions	Water	.998207	H – 11.18%; O – 88.81%
	Air	1.205E-03	C – 0.0124%; N – 75.527%; O – 23.178%; Ar – 1.283%
Tank	SS-304	8.00	C – 0.183%; Si – 0.9781%; P – 0.0408%; S – 0.0257%; Cr – 20.076%; Mn – 1%; Fe – 69.038%; Ni – 8.659%
Detector	Ar/CO2 (85/15)	4.8779E-04	C – 4.094%; O – 10.884%; Ar – 85%
Detector	Ar/CO2 (97/3)	4.2835E-04	C – 0.8187%; O – 2.177%; Ar – 97%
D-D PNG	Copper	8.96	Cu – 100% (⁶³ Cu – 69.15%; ⁶⁵ Cu – 30.85%)
D-D PNG	Kovar	8.96	Fe – 53.47%; Ni – 28.85%; Co – 17.15%; Mn – 0.17%; Si – 0.15%; Ti – 0.03%; Cu – 0.03%; Al – 0.0012%; Mo – 0.0138%

Two scenarios were considered for the simulations. The first was normal operating conditions, in which the assembly and all shielding components were in default configurations. The second was a loss of shielding condition, in which the shielding, mainly water, was removed and replaced with air to simulate an accident scenario. The two scenarios were selected to compare expected dose to workers under routine operation and an emergency scenario.

RESULTS AND DISCUSSION

Dose at selected detector locations

Based on the calculated results, secondary photon dose dominated the response for most of the six detector positions, while neutron and primary photon dose contributed smaller portions of the total dose, as shown in Figure 4.

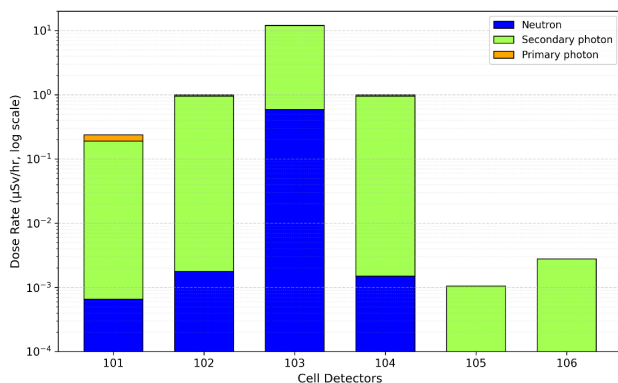


Figure 4: Dose rate contribution per detector in normal conditions

The highest ambient dose was obtained at detector 103 with a total of $1.20 \times 10^1 \mu\text{Sv/hr}$. This was followed by detectors 102 and 104, which had approximately the same total dose rate of $1.00 \mu\text{Sv/hr}$. Detector 101 showed an even lower dose rate tally of $2.38 \times 10^{-1} \mu\text{Sv/hr}$, while detectors 105 and 106, located above the tank, showed the lowest values at $1.05 \times 10^{-3} \mu\text{Sv/hr}$ and $2.77 \times 10^{-3} \mu\text{Sv/hr}$, respectively, with no neutron and primary photon contributions. As

expected, the dose rate is asymmetric due to the position of the neutron source in the model. This resulted in a shorter distance to phantom 103, which had the highest dose rate.

These results indicate that total dose rates under normal operation are highly dependent on the source position in the model geometry. The higher dose rate at detector 103 shows that locations close to the PNG receive the largest contribution, while the much lower dose at detectors 105 and 106 indicates significant dose reduction above the tank due to water shielding and farther distance from the PNG. The high contribution of secondary photon dose for most of the detectors suggests that the water reduces the direct neutron interactions in the detectors, although neutron interactions in the water still produce measurable 2.22 MeV photons that reach the detectors.

From a radiation protection perspective, the dose rates under normal operations can be evaluated against the expected operating time of the D-D PNG. Assuming a total PNG operating time of 500 hours, continuous occupancy at the highest dose detector location, detector 103, would correspond to an accumulated dose of approximately 6.0 mSv. This is about 30% of the occupational effective dose limits of 20 mSv per year averaged over five consecutive years, and about 12% of the 50 mSv limit for any single year based on the Code of Philippine Nuclear Research Institute Regulations Part 3 (Philippine Nuclear Research Institute [PNRI] 2021). The other detector locations would result in substantially lower accumulated doses over the same operating period. Under conservative assumptions, continuous occupancy for the full expected PNG operating time in the highest dose rate location would result in an accumulated dose still below the occupational limit.

Spatial dose distribution from mesh tallies

The mesh tallies in the xy and xz planes were used to visualize ambient dose distribution around the assembly. The phantom tallies provided discrete point values, while the mesh tallies show how the dose field extends from the source through the surrounding regions. Figure 5 and Figure 6 show the spatial distributions of neutron and secondary photon dose rates for the xy plane and the xz plane, respectively.

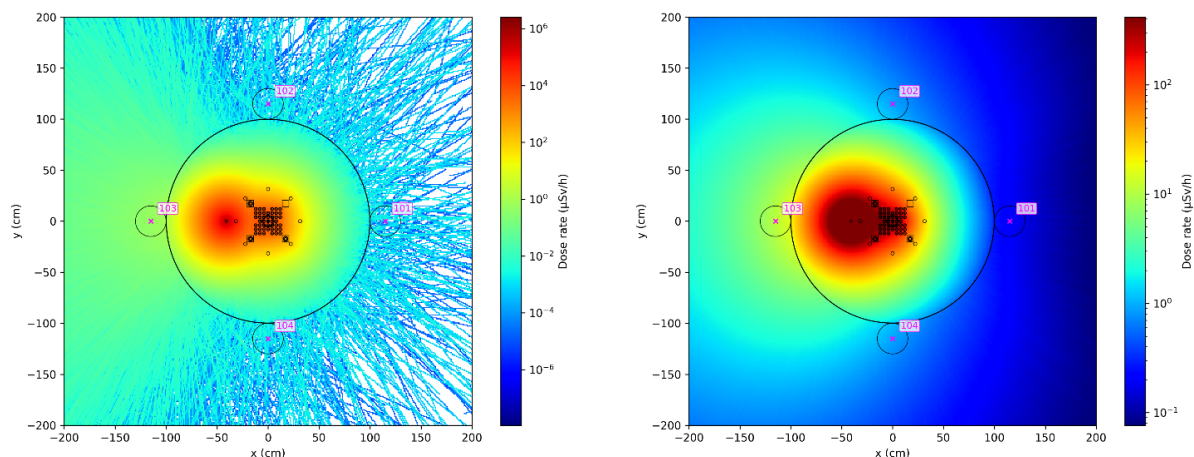


Figure 5: Neutron and secondary photon dose maps in xy plane for normal operating condition.

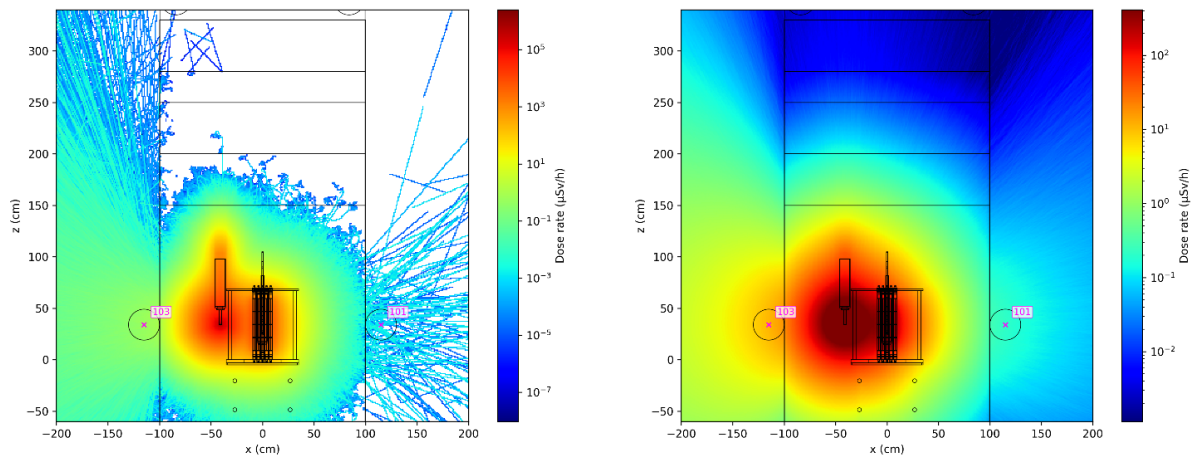


Figure 6: Neutron and secondary photon dose maps in xz plane for normal operating condition.

In the xy plane, the highest doses are concentrated around the source region and decrease outward with distance from the assembly for neutron and secondary photons. The dose distribution for neutrons and secondary photons was not radially uniform due to the relative position of the source and the surrounding geometry. The heatmap results coincide with the phantom tallies in Figure 4, where the highest total dose rate was obtained at detector 103 in the order of $10 \mu\text{Sv/hr}$, side detectors 101, 102, and 104 in the order of 10^{-1} to $1 \mu\text{Sv/hr}$, and the upper detectors 105 and 106 were in the order of $10^{-3} \mu\text{Sv/hr}$. The neutron radiation was the highest contributor for detector 103, while secondary photon dose was more dominant at the other detector locations. For the xz plane, the dose field varied with the vertical position of the model. In this plane, the highest dose was still observed at detector 103, which was nearest to the source. The secondary photon doses also showed a similar spatial dose distribution.

Loss of Shielding

The loss of shielding (LOS) scenario considered the condition in which the water normally surrounding the source and core components was absent and replaced with air. Figure 7 shows the dose values of the six detectors under the LOS scenario. Under LOS conditions, neutron dose dominated the dose rate contribution across all detectors, while secondary and primary photons became minor in comparison. Compared with normal operation, total dose rates increased from the order of 10^{-3} to $10^1 \mu\text{Sv/hr}$ to the order of 10^1 to $10^3 \mu\text{Sv/hr}$, depending on detector location. This corresponds to an increase of approximately two to five orders of magnitude showing the strong effect of water removal.

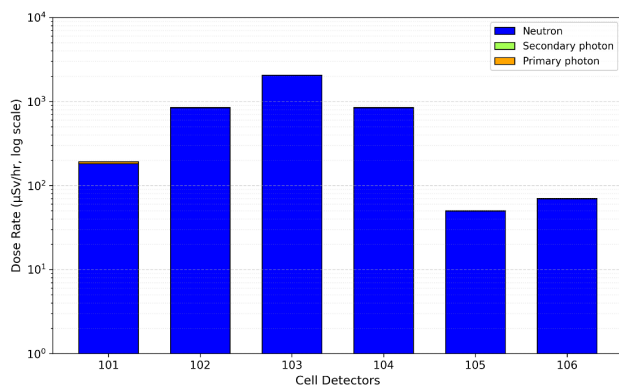


Figure 7: Dose rate contribution per detector in LOS condition

This increase is attributed to neutrons traveling farther distances through the system, or neutron streaming, and interacting with air in the detector locations instead of being moderated, scattered, and absorbed by water. This resulted in more neutron interactions at the

detector locations, increasing both neutron and secondary photon dose rates (Wang and Sjoden 2021). Similarly, the primary photon dose rate increased because of reduced attenuation and increased mean free path for photons traveling from the reactor fuel in the core to the detectors (Tekin et al. 2019). This shows that the loss of the water as shielding not only increased the dose rates across all detectors but also changed the radiation field from being largely photon dominated to strongly neutron dominated.

Figure 8 shows the relative change in total dose rate across all detectors between normal and LOS conditions. Detector locations 105 and 106 showed the highest relative increase, with increases up to five orders of magnitude, while detector 103 showed the smallest relative increase, at about two orders of magnitude. The locations of detectors 105 and 106 are the most shielded areas under normal conditions and correspond to the reactor platform where students and researchers perform experiments.

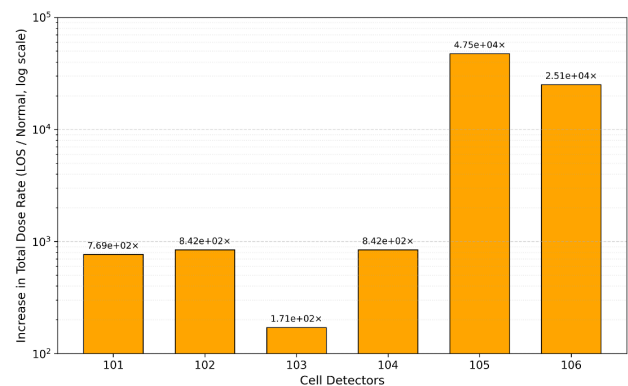


Figure 8: Increase in total dose rate across all detectors between normal and LOS condition

As shown in Figure 9, the total dose rates from normal and LOS conditions indicate that detectors 105 and 106 showed the highest relative increase but remained the locations with the lowest total dose rates. In contrast, location 103 showed the smallest relative change but remained the location with the highest total dose rate. This indicates that detectors 105 and 106 correspond to the least exposed areas in both normal operation and LOS conditions, while detector 103 remains the most critical location for dose assessment.

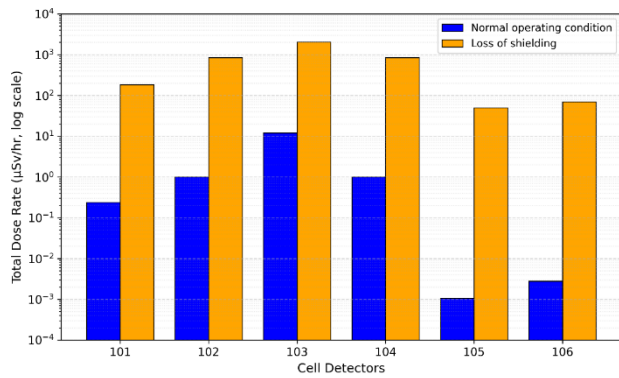


Figure 9: Total dose per detector in normal operating conditions vs LOS scenario

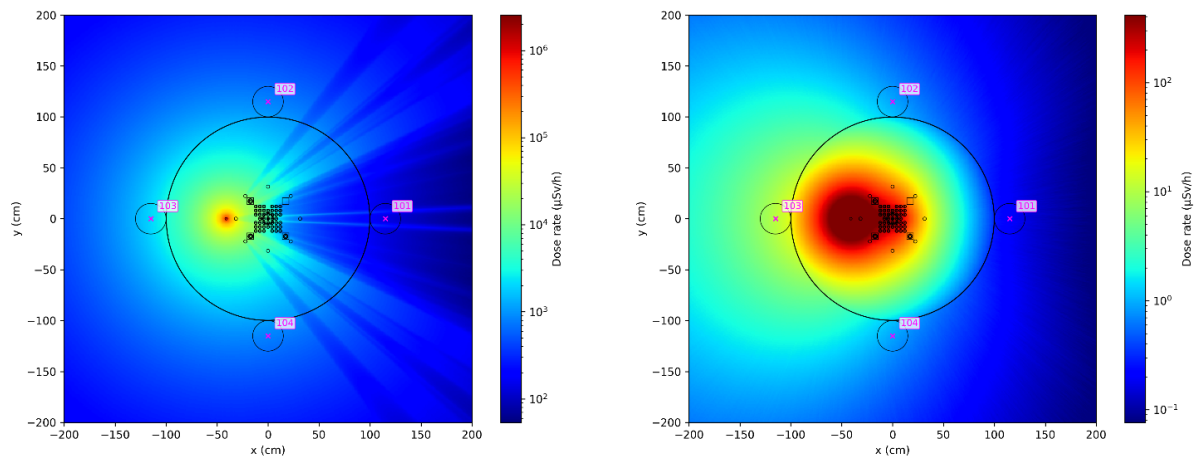


Figure 10: Neutron and secondary photon dose maps in xy plane for LOS scenario

A similar shadowing effect is observed in the xz plane, as shown in Figure 11. The left side of the model shows a more gradual dose distribution because there is less obstruction from the neutron

source, while the right side and upper regions are obstructed by the core, resulting in the observed shadowing effect.

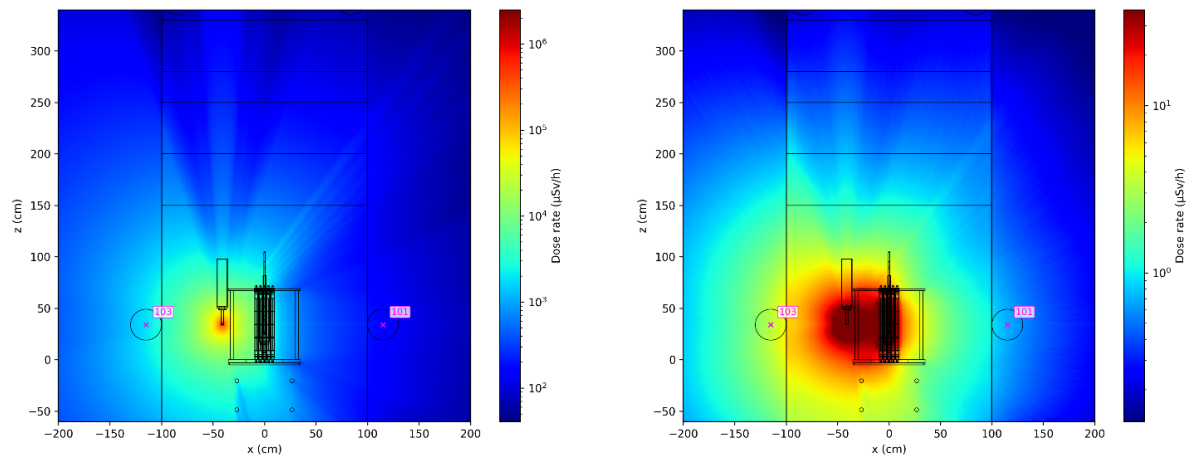


Figure 11: Neutron and secondary photon dose maps in xz plane for LOS scenario

Since the LOS scenario is classified as an emergency, standard occupational dose limits do not apply. Hence, exposure estimates must be used to determine the maximum allowable response window to ensure personnel safety. It is highly advantageous that the D-D PNG driving the reactor is electrically operated, so it can be turned off to terminate the radiation source in case of any deviation from normal operation. However, even in the unlikely scenario that the PNG cannot be turned off, the maximum response time for responders to address the emergency is limited by the peak dose rate of 2.05 mSv/h at detector 103. To ensure minimal

exposure to responding personnel, operations must be managed within a tight timeframe. A rapid response window of 2 to 4 hours would result in a potential exposure of only 4.1 to 8.2 mSv at the most severely affected location, well below typical emergency reference levels.

Even at the lower-boundary locations like detectors 106 and 105, where dose rates are 0.07 mSv/h and 0.05 mSv/h respectively, any prolonged presence during a failure-to-shutdown scenario would eventually introduce unnecessary accumulation over time. These

calculations assume continuous exposure at the detector locations, serving as a conservative upper bound for emergency planning. These findings indicate that an unmitigated LOS condition carries potential radiological consequences. The scenario must be treated as an emergency requiring immediate access restriction, rapid system shutdown protocols, and a strictly optimized personnel deployment strategy to keep emergency exposures as low as reasonably achievable.

CONCLUSION

This study provided a computational dose assessment of an accelerator-driven subcritical assembly, based on the PRR-1 SATER, using a Deuterium-Deuterium Portable Neutron Generator as an alternative external neutron source. Using MCNP5 simulations, neutron and photon dose distributions were evaluated for normal operation and loss of shielding conditions. Dose rates were assessed using mesh tallies in selected planes and air-filled phantoms/detectors positioned around the assembly to estimate local dose at areas relevant to personnel access and operation.

Under normal operation, dose levels remained generally low, indicating that the surrounding water provides adequate shielding for the evaluated configuration. The highest total dose rate was obtained at detector 103 at $1.20 \times 10^1 \mu\text{Sv/hr}$, while the other detector locations were substantially lower. Assuming a total PNG operating time of 500 hours, continuous occupancy at detector 103 would correspond to an accumulated dose of 6.0 mSv, which remains below the occupational dose limit of 20 mSv per year averaged over five years. This indicates that the shielding configuration is sufficient for normal operation under the conservative exposure assumption in this study.

The LOS results show that water removal causes a substantial increase in dose rate across all detectors, with detector 103 reaching $2.05 \times 10^3 \mu\text{Sv/hr}$. The radiation field changed from being secondary photon dominated to neutron dominated, showing the importance of water as a moderating and shielding material. Since LOS represents an emergency scenario, the results are better interpreted in terms of response time and exposure management. At the highest dose-rate location, a response window of 2 to 4 hours would correspond to a potential exposure of approximately 4.1 to 8.2 mSv. This indicates that the LOS condition carries potential radiological consequences and should require immediate access restriction, rapid system shutdown, and optimized personnel deployment to minimize exposure.

Neutron and photon dose distributions of the D-D PNG-driven configuration were evaluated by identifying the highest dose locations and comparing values under routine and emergency conditions. The results provide an initial computational basis for radiation safety, shielding assessment, and emergency planning for the use of a portable neutron generator in subcritical assemblies. Future work should include experimental validation of the calculated dose rates and further refinement of the model to support the radiation protection program of PRR-1 SATER.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

CONTRIBUTIONS OF INDIVIDUAL AUTHORS

Ariel Jorge F. Payot: Writing – Original draft, Visualization, Data Analysis. **Art Marcelo Andallo II:** Writing – review & editing, Data Analysis. **Alvie Asuncion-Astronomo:** Writing – Methodology, Conceptualization, Data curation, Software modelling, Investigation, review & editing.

DECLARATION OF THE USE OF AI

ChatGPT 5.4 was used in the preparation of this manuscript for organization, editing, and grammar checks. All scientific content, data analysis, interpretations, and conclusions were developed by the authors, who take full responsibilities for the integrity of the content.

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ANNEX A: Phantom tally results with relative error

Table A: Normal condition dose rate across phantoms per component

Phantom	Neutron (μSv/hr)		Secondary Photon (μSv/hr)		Primary Photon (μSv/hr)		Total (μSv/hr)	
	Tally	Rel Error	Tally	Rel Error	Tally	Rel Error	Tally	Rel Error
101	6.57E-04	3.21E-01	1.89E-01	6.20E-03	4.82E-02	2.25E-02	2.38E-01	3.21E-01
102	1.78E-03	2.07E-01	9.51E-01	2.40E-03	4.68E-02	2.30E-02	1.00E+00	2.08E-01
103	5.90E-01	1.87E-02	1.14E+01	6.00E-04	5.59E-02	2.14E-02	1.20E+01	2.84E-02
104	1.50E-03	2.28E-01	9.52E-01	2.40E-03	4.87E-02	2.29E-02	1.00E+00	2.29E-01
105	0.00E+00	0.00E+00	1.05E-03	8.91E-02	0.00E+00	0.00E+00	1.05E-03	8.91E-02
106	0.00E+00	0.00E+00	2.77E-03	5.69E-02	0.00E+00	0.00E+00	2.77E-03	5.69E-02

Table B: LOS condition dose rate across phantoms per component

Phantom	Neutron (μSv/hr)		Secondary Photon (μSv/hr)		Primary Photon (μSv/hr)		Total (μSv/hr)	
	Tally	Rel Error	Tally	Rel Error	Tally	Rel Error	Tally	Rel Error
101	1.82E+02	1.40E-03	7.26E-01	3.30E-03	9.57E+00	2.10E-03	1.83E+02	1.39E-03
102	8.40E+02	7.00E-04	1.76E+00	1.90E-03	9.56E+00	2.10E-03	8.42E+02	6.99E-04
103	2.05E+03	4.00E-04	3.55E+00	1.30E-03	9.26E+00	2.10E-03	2.05E+03	3.99E-04
104	8.40E+02	7.00E-04	1.76E+00	1.90E-03	9.59E+00	2.00E-03	8.42E+02	6.99E-04
105	4.97E+01	3.70E-03	1.68E-01	7.60E-03	6.36E-01	1.06E-02	4.99E+01	3.69E-03
106	6.94E+01	2.70E-03	1.84E-01	6.90E-03	6.24E-01	1.07E-02	6.96E+01	2.69E-03