SNS-OPM-ATT 2.B-10.a
Unreviewed Safety Issue (USI) Evaluation Form

I. Title of USI Evaluation

USI Evaluation for the Use of Far West Area Radiation Monitors as PPS Interlocked Area Radiation Monitors

II. Description of Proposed Activity (or discovered condition) (use attachments if necessary):

The Spallation Neutron Source (SNS) Personnel Protection System (PPS) uses an extensive network of dedicated sensors, logic devices, and final elements to prevent or mitigate exposure of personnel to prompt radiation hazards associated with the accererator. The credited safety functions and auxiliary safety assurance features of the PPS are listed in Section 3.2.4.1 of the Final Safety Assessment Document for Proton Facilities (FSAD-PF) [1]. The following credited safety function of the PPS is important to this USI evaluation (USIE).

> *Shut off beam if radiation levels set by the SNS radiation safety officer (RSO) are reached at PPS-interlocked area radiation monitor locations.*

The credited safety function shown above is accomplished by an array of interlocked area radiation monitors (IRM) installed at select locations along the path of the proton beam. The locations chosen for the IRMs are where higher-than-expected prompt radiation levels may occur because of beam loss, insufficient shielding, or tunnel penetrations. If significantly elevated radiation levels are detected that are inconsistent with the area classification, the IRM sends a signal to the front end of the accelerator to trip the proton beam off.

The SNS RSO determines the location and the number of IRMs, subject to review by the radiation safety committee (RSC). There are currently 47 IRMs in use at the SNS. The RSO also selects the trip levels in terms of dose rate (mrem/hour) and quality factors (QF) for PPS IRMs.

Since the commissioning phase of SNS, a specific model of area radiation monitor (ARM) has been deployed as PPS IRMs. That ARM is a Chipmunk IVa [2], which is a tissue equivalent, ion chamber based ARM developed by Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois. The SNS adopted the design of the Chipmunk IVa, and contracted RIS Corporation of Knoxville, Tennessee to produce them [3, 4, 5]. The Chipmunk IVa is also referred to as just a Chipmunk through the remainder of this document. Figure 1 contains an image of a Chipmunk.

Chipmunks are currently the only certified ARMs that can be used to fulfill the aforementioned credited safety function of the PPS. This USIE assesses an alternative ARM that is manufactured by Far West Technology, Inc. of Goleta, California as a PPS IRM. Far West Technology, Inc. produces many different radiation measurement devices. The specific devices being investigated in this USIE are a model 6030A ion chamber detector [6, 7] coupled with a model 6016-BNL digital display/controller [8].

The model 6030A ion chamber detector includes a model 1055 ion chamber, an electrometer, and a high voltage power supply in one housing. It is designed for both pulsed and steady state radiation fields. The model 1055 ion chamber is the same ion chamber used in the Chipmunk, and consists of a 3.4 liter propane gas sensing volume that is sensitive to both gamma and neutron radiation. The electrometer of the 6030A is housed in a sealed compartment to shield it from atmospheric and electrical noise.

Figure 1: Chipmunk

The model 6016-BNL digital display/controller is designed to be used as a readout for the model 6030 ion chamber detector. It contains a front panel display and a microprocessor that provides user-defined alarms and trip signals, a high voltage pulse check, setup and operational controls for the detector, internal fault detection, and an input/output (I/O) interface. A direct current (DC) power supply in the model 6016-BNL digital display/controller provides power for both the display/controller and the ion chamber detector. The specific combination of 6030A detector and 6016-BNL display/controller is also referred to as just a Far West through the remainder of this document. Figure 2 contains images of the two components that make up a Far West ARM.

Model 6030A Ion Chamber Detector   Model 6016-BNL Digital Display/Controller

Figure 2: Far West Components

The SNS is a pulsed linear particle accelerator that operates at 60 Hz, and accelerates hydrogen ions (H^-) up to 1.3 GeV. The hydrogen ions that are accelerated in the linear accelerator (linac) are stripped of their electrons (leaving behind protons) and injected into the accumulator ring, where multiple bunches of protons are accumulated (up to 1,060 turns around the ring) before being sent to the mercury target for neutron production via the spallation of mercury. The proton bunches are very short (< 1 μs) in terms of pulse width.

Due to the unique configuration of the SNS, there are key characteristics that a PPS IRM needs. First, the IRM needs to be able to detect and measure prompt radiation fields produced by beam spills from short, intense pulses of radiation. Second, the IRM needs to be able to detect both gamma and neutron radiation, since the radiation produced by beam losses is characterized by both. As part of this requirement, the IRM needs to be able to be scaled for different ratios of gamma and neutron fields (i.e., QF). Third, the IRM needs to have a fail-safe design. What this means is that a failure in the IRM (e.g., diagnostic failures, hardware failures, etc) needs to put the accelerator into a safe state. Fourth, the IRM needs to satisfy the high availability requirements of the PPS such that the SNS can reliably deliver its scheduled neutron production time.

Chipmunks were developed to satisfy the four requirements stated above, and by most measures have proven to be effective PPS IRMs. However, the Chipmunks require a large amount of maintenance to ensure they meet operational expectations. The principal causes of down-time are failures in the electrometer and high voltage boards. Both of these components are very susceptible to humidity and moisture. As well, the electrometer board is a custom built component that uses obsolete parts, thus making it difficult to repair and/or replace. Finally, SNS's ability to procure new Chipmunks has been marginal, at best. The SNS is in need of a proven, commercial-off-the-shelf (COTS) alternative to the Chipmunk to ensure future operational needs are met.

Next, it is beneficial to discuss how the Chipmunk interfaces with the PPS. Figure 3 is provided to help facilitate this discussion.

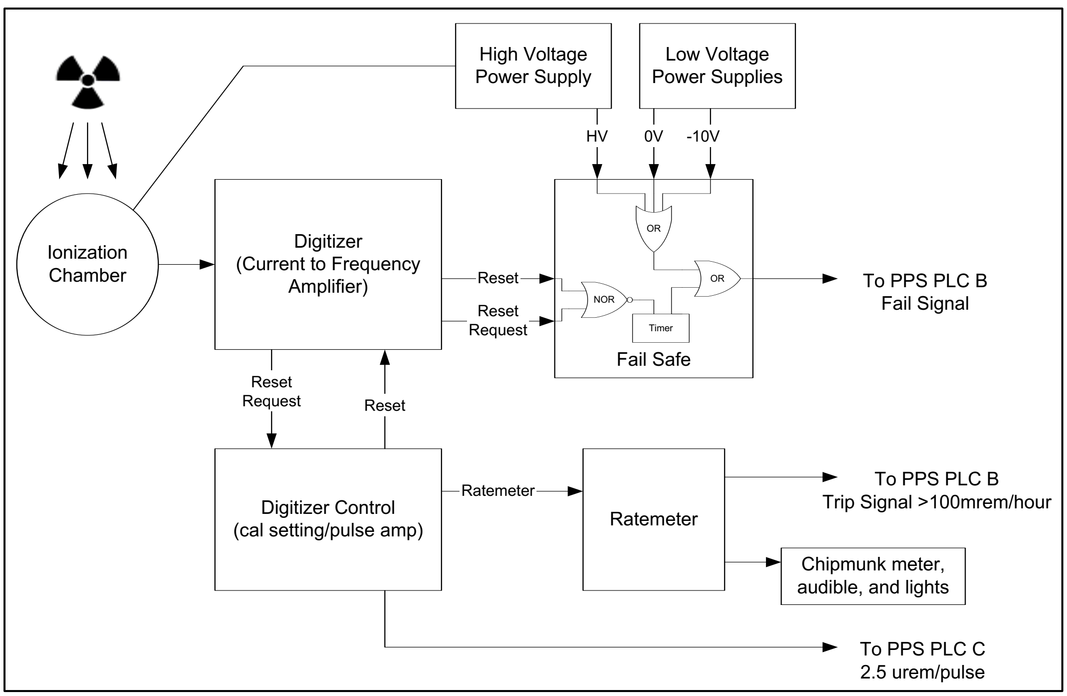

Figure 3: Simplified Chipmunk Block Diagram

The Chipmunk sends three signals to the PPS. Two signals, the fail signal and the trip signal, are sent to Programmable Logic Controller (PLC) B. The third signal, the pulse signal, is sent to PLC-C. Each of these three signals is explored further below.

The fail signal is a summation of four fail-safe diagnostic checks throughout the power supply, ion chamber, and digitizer. It sends a trip signal to PLC-B if any monitored value is outside of its designated ranges. Once the fail signal is received, the PPS reaches back to the front end of the accelerator and trips the proton beam. The fail signal is also sent if there is an absence of diagnostic pulses or abnormal timing of the pulses. A USI Determination (USID) was written in 2009 [9] that increases the time the fail signal needs to persist to

30 seconds before it trips off the front end. This timing increase was incorporated to decrease the number of hard trips of the front end from spurious fail signals.

The second signal that is sent to PLC-B is the trip signal, which is currently set to > 100 mrem/hour for all Chipmunks at the SNS. The trip signal is an instantaneous measure of the dose rate being calculated by the Chipmunk, and trips the front end of the accelerator upon receipt.

The third signal that the Chipmunk transmits is a pulse signal that is sent to PLC-C (which also serves as a high speed counter). Each pulse that is sent to PLC-C is equivalent to 2.5 μrem. The high speed counter utilizes these pulses and calculates 10 second, 60 second, and 15 minute rolling averages. If the dose rate is ≥ 5 mrem/hour averaged over a 15 minute period, the Chipmunk sends an alarm signal. If the dose rate is ≥ 20 mrem/hour averaged over a 15 minute period, the Chipmunk trips the front end of the accelerator.

Note that there are other Chipmunk alarms and trips that utilize the three signals discussed above. These are the flatline alarm, the Machine Protection System (MPS) fault, and the loss of counts trip. The flatline alarm locks in if the 10 second rolling average does not change in a two hour time period. The MPS fault was added in [9], and is intended to offset the change in timing to 30 seconds for the fail signal. The MPS fault is a fast protect trip that only changes the phase of the radio frequency quadripole (RFQ), which is easier to recover from than a hard trip of the front end. The loss of counts trip was added in a USID that was written in 2006 [10]. A vulnerability was found in the PLC programming in four Chipmunks such that the 15 minute rolling average was not updating correctly. The loss of counts trip is activated if the pulses received by PLC-C do not update within a specified period of time based on the Chipmunk's QF setting.

There are two important specifications that are worth documenting and comparing between the Chipmunk and Far West, the output frequency range and the linear detectable range. The output frequency range of a Chipmunk is from 0.01 Hz to 10,000 Hz, and the linear detectible range is 0.13 mrem/hour to 9,000 mrem/hour [2]. The Far West has an output frequency range of 0 Hz to 10,000 Hz [7], and the linear detectible range of the model 6030A detector is 0.1 mrem/hour to 1,000 mrem/hour [11]. This is not to say that the Far West ARM cannot detect radiation fields > 1,000 mrem/hour, just that the manufacturer does not guarantee any level of accuracy above that value. Studies performed at SNS (described later in this document) show that the Far West detector is able to detect radiation levels > 1,000 mrem/hour.

The Far West 6016-BNL display/controller provides two user-adjustible alarms for elevated radiation levels. The first alarm is the highest priority, and is referred to as the high trip. The high trip actuates the red light emitting diode (LED) on the front panel of the controller (shown in Figure 2). The second alarm is the second highest priority and is referred to as the low trip. The low trip actuates the yellow LED on the front panel of the controller. Both alarms have dedicated relays that control a digital output for use by an external system (such as a PLC-based system like the PPS). Both alarms can be manually set to a specific level (mrem/hour) with a specific delay (number of seconds the alarm is activated before the relay opens). Both alarm relays are fail-safe, which means that if power is removed from the relays, they will automatically open and send a trip signal. Note that these relays will also trip open on a loss of power to the Far West.

There is also a third fail relay in the Far West, which is opened if there is a failure in the ARMs functionality. There is no LED for the fail relay; instead, if the relay opens, the green LED on the front panel is turned off. The fail relay is used for various fail-safe diagnostic checks within both the 6030A ion chamber detector and the 6016-BNL digital display/controller. Those diagnostic checks are (1) the microprocessor watchdog check, (2) the loss of high voltage power check, (3) the electrically erasable programmable read-only memory (EEPROM) failure check, (4) the timing check, and (5) the loss of connectivity to the ion chamber check.

Prior to going into the details about the various diagnostic checks in the Far West, it is beneficial to explore two features of the Far West, the zero bias and high voltage pulse check, and compare those features to analogous features in the Chipmunk. The zero bias and high voltage pulse check serve to continuously check the circuitry of the Far West in the absence of a check source.

The 6030A ion chamber detector is biased such that it always sends a signal of 50 Hz to the 6016-BNL display/controller. The conversion factor for the 6030A ion chamber detector is 0.1, so this zero bias translates to 0.5 mrem/hour. The zero bias is always applied to the signal coming from the 6030A detector, but is subtracted out by the 6016-BNL display/controller such that it is not applied to either the display or either the high or low alarm signal (this functionality can be altered by the user). The zero bias is not affected by the QF setting.

The high voltage pulse check was applied to the FarWest due to the discovery of failure mode that was not fail-safe, where the detector would not send a fail signal if the high voltage power supply was removed from the ion chamber. The high voltage pulse check originates in the 6016-BNL controller and is a pulse that is sent to the 6030A ion chamber detector that simulates the current produced by a radiation pulse. That pulsed signal is sent back to the controller and compared to a minimum level. If the pulse is not greater than the minimum level, the fail relay is opened.

As stated above, the Far West zero bias and high voltage pulse check are analogous to a check source. The SNS Chipmunks utilize a 5 μCi ^{137}Cs check source to continuously ensure the ARM is responding appropriately (the check source is placed next to the ion chamber inside the yellow housing of the Chipmunk). At a QF of 2.5, the 5 μCi check source is equal to approximately 0.5 mrem/hour. If the check source is removed, the Chipmunk will issue a fail signal.

The zero bias signal is the basis for the timing check, since the 6016-BNL controller has a user-defined time interval for the zero bias signal to not be present before the fail relay is opened. Note that the timing check is analogous to the loss of counts trip in the Chipmunk. The zero bias signal is also the basis for the loss of connectivity check between the controller and detector. If the 6030A detector is not appropriately connected to the 6016-BNL controller, the zero bias signal will not be sent, thus opening the fail relay in the controller.

The final two diagnostic checks that factor into the fail relay for the Far West are the microprocessor watchdog check and the EEPROM failure check. The watchdog check utilizes a dedicated circuit that pings the microprocessor every second. If that ping is unsuccessful, the watchdog will reset the microprocess which opens both alarm relays and the fail relay. The EEPROM which stores the user-defined parameters (like alarm level and timing) is also pinged every second. If that ping is unsuccessful because the memory fails or the memory chip is removed, the fail relay is opened.

There is one final Far West setting that is discussed in this USIE. The QF can be set at any integer between 1 and 20. The Chipmunk has QF settings of 1, 2.5, 5, and 10. Thus, the Far West has a larger QF range than the Chipmunk. This is somewhat academic, though, since all of the PPS IRMs in use at the SNS have a QF setting of 2.5. The SNS RSO will determine the QF setting for Far West PPS IRMs.

Next, it is beneficial to explore how a Far West ARM could hypothetically be used as a PPS IRM. Before going into this discussion, it is worth noting that the SNS RSO has discretion over setting PPS IRM trip points. This discussion is only provided to show how a Far West ARM can provide similar trip capability as a Chipmunk. One potential way the Far West could be used is by setting both the high alarm and the low alarm to ≥ 20 mrem/hour. The alarm delay for both trips would hypothetically be instantaneous, thus both alarms would open their associated relays immediately upon reaching a radiation field of ≥ 20 mrem/hour.

These instantaneous trips are analogous to the 100 mrem/hr instantaneous trip in a Chipmunk. Each of the two trips would be sent to redundant PLCs in the PPS (i.e., the high trip would be sent to PLC-A, and the low trip would be sent to PLC-B). This configuration creates redundancy in the trip signals, reducing the probability that a single failure disables functionality. Note that in this configuration, the Far West does not issue a trip that is the product of a rolling average (like the Chipmunk PLC-C pulse trip of ≥ 20 mrem/hour based on a 15 minute rolling average). This is acceptable, since the instantaneous trip at ≥ 20 mrem/hour is conservative when compared to a trip based on a 15 minute rolling average. The purpose of the Chipmunk 15 minute rolling average trip was to trip the front end of the accelerator if there was an ongoing beam spill that is insufficient to quickly trip the beam at 100 mrem/hour, but could still provide a significant personnel dose if it went unchecked for an extended period of time.

Table 4.4. of the FSAD-PF [1] states that the time frame for a Chipmunk signal to actually trip the proton beam is ~ 2 seconds. This time frame is dominated by the time it takes the trip signal issued by the Chipmunk to progress through PPS PLCs to the front end critical devices. The time it takes the trip signal to actually be issued by the Chipmunk is negligible in the scope of 2 seconds. The reaction time for the Chipmunk and Far West to detect a pulsed radiation field is primarily based on the time it takes the ion chamber to collect a charge; that value is 5 milliseconds for the model 1055 ion chamber [2], which is the ion chamber used for both Chipmunk and Far West detectors. It is a reasonable assumption that the Far West electronics will not appreciably impact the time required to trip the proton beam when compared to the Chipmunk (see discussion above comparing output frequencies between the two models).

Next, it is worthwhile to compare how Chipmunks and Far Wests respond to different radiation fields. The data that is presented for this comparsion was collected on July 26, 2017 in the Radiation Instrument Calibration Laboratory (RICL) at Oak Ridge National Laboratory (ORNL). This comparison investigates the dose rate output for the Chipmunk and Far West in radiation fields produced by a ^{137}Cs, a ^{252}Cf, and a Plutonium-Beryllium (Pu-Be) source. The radiation field produced by a ^{137}Cs source is characterized by 661.7 keV gammas. The radiation field produced by a ^{252}Cf source is characterized by both gammas and neutrons from spontaneous fission. The prompt gammas are produced from the spontaneous fission, while the neutrons that are emitted follow a Maxwellian distribution with a mean neutron energy of approximately 2 MeV. The radiation field produced by a Pu-Be source is principally characterized by neutrons from the (α,n) reaction. The neutrons that are produced are in a spectrum with an average neutron energy of approximately 4.2 MeV.

Figure 4 provides the comparison data for the ^{137}Cs source. Both ARMs had a QF of 1. The maximum dose rate produced from this source test was 1,000 mrem/hour, which is well above the highest alarm level of the Chipmunk (i.e., 100 mrem/hour). Figure 4 shows that both ARMs respond well to a gamma radiation field, and the Chipmunk tends to better predict the actual dose rate when compared to the Far West. At 100 mrem/hour, the Chipmunk is -5% off, while the Far West is -8% off.

Figure 5 provides the comparison data for the ^{252}Cf source. Both ARMs had a QF of 2.5. The maximum dose rate produced from this source test was only 95 mrem/hour, but the data proves to be interesting, since it characterizes the ARM response under a mixed neutron and gamma radiation field. Figure 5 shows that both ARMs do not respond as accurately in a mixed radiation field as they do in a purely gamma radiation field. Both ARMs respond fairly similarly, with the Chipmunk responding better from 3 mrem/hour to 40 mrem/hour, and the Far West responding better from 40 mrem/hour to 95 mrem/hour. At 95 mrem/hour, the Chipmunk is -19% off, while the Far West is -16% off.

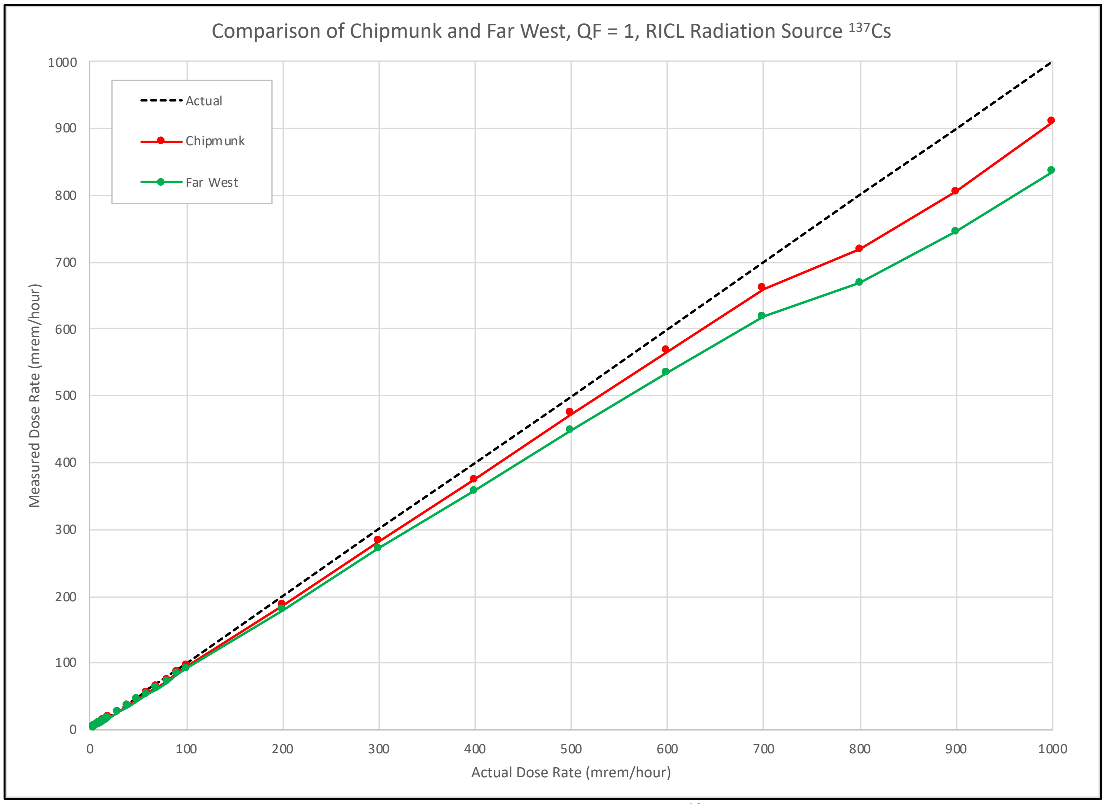

Figure 4: RICL Comparison with ^{137}Cs Source

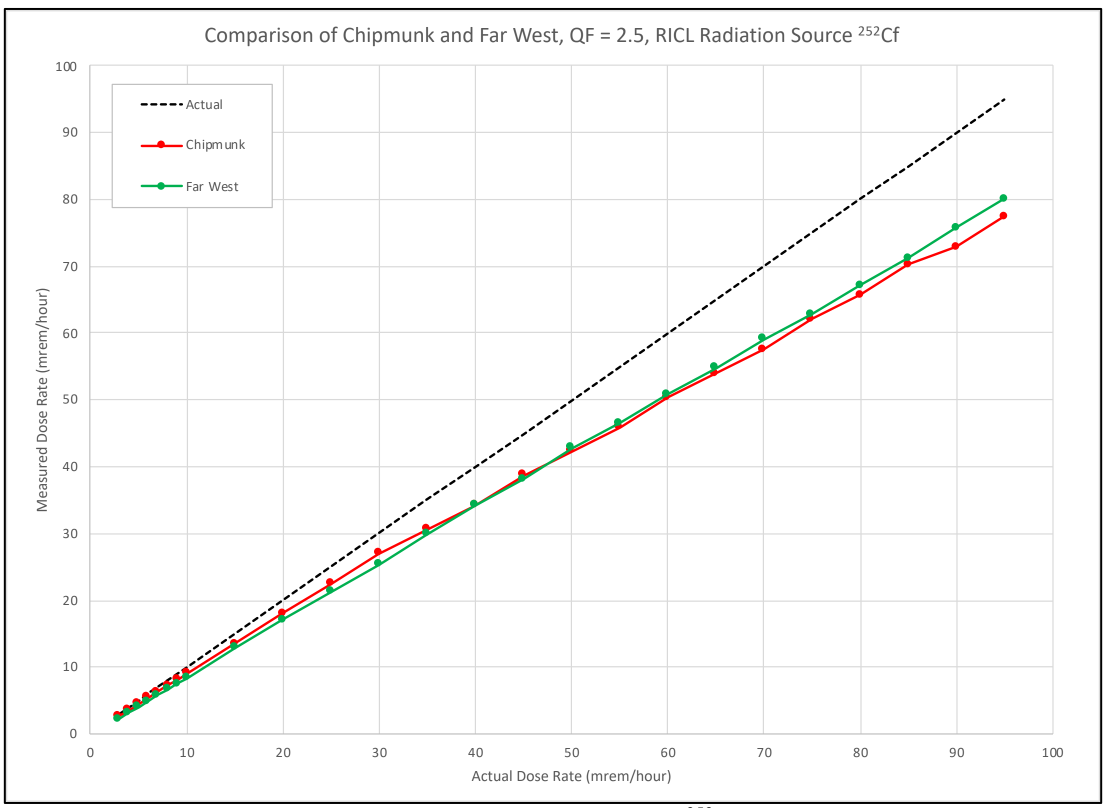

Figure 5: RICL Comparison with ^{252}Cf Source

Figure 6 provides the comparison data for the Pu-Be source. Both ARMs had a QF of 5. The maximium dose rate produced from this source test was 150 mrem/hour. Figure 6 shows that in a strong neutron field, both ARMs overpredicted the dose rate. This is markedly different than the ^{137}Cs gamma field and the mixed field of the ^{252}Cf source, which both had an underprediction of the dose rate. At 100 mrem/hour, the Chipmunk is +23% off, while the Far West is +19% off.

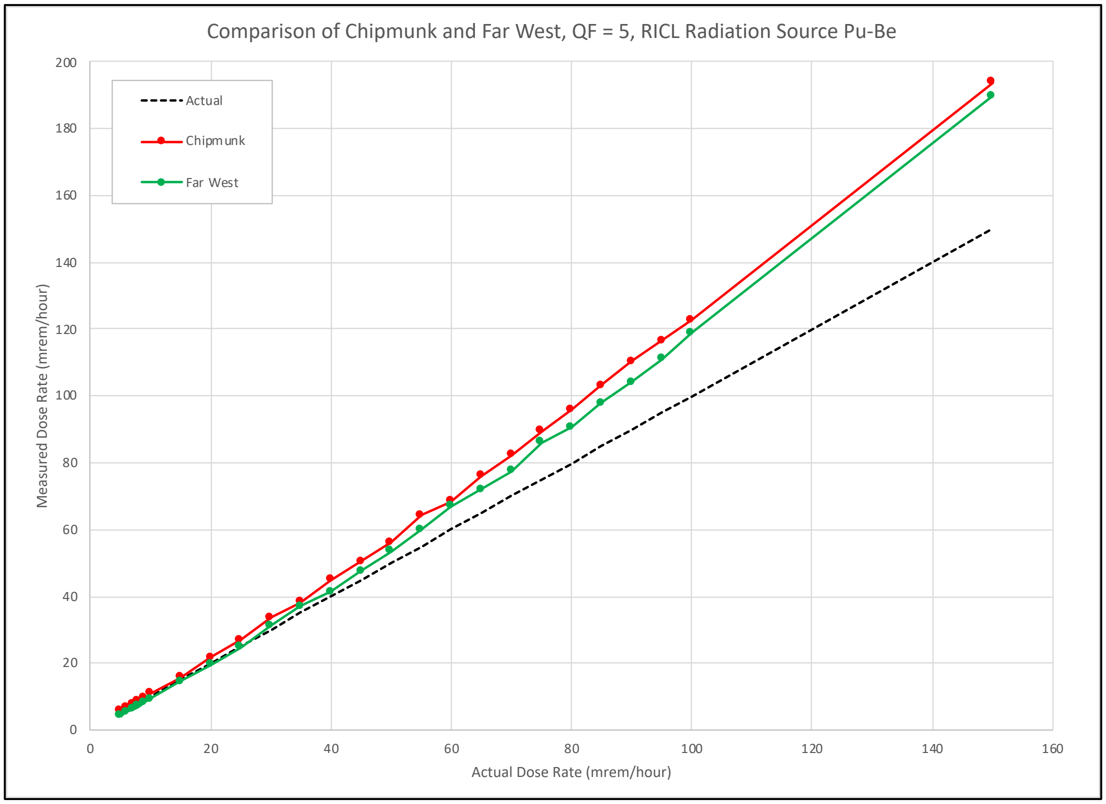

Figure 6: RICL Comparison with Pu-Be Source

Figures 4, 5, and 6 are provided to show that a Far West responds relatively similar to a Chipmunk in gamma and neutron radiation fields. This is expected, since both use the same ion chamber. Note that there is no expectation that the two ARMs would respond exactly the same to a radiation field. They contain different hardware, and process the current signal from the ion chamber in different ways. Though there are differences in the measured dose rates, the nature of those differences are not within the purview of this USIE. Remember, the credited function of the Chipmunk is to trip the proton beam upon reaching a high radiation field. It is not credited with measuring the radiation field with any degree of specificity. Because there are differences in the measured dose rates, another comparison is provided below.

The second comparision presented in this USIE uses data collected from a Chipmunk and a Far West placed next to each other in the warm linac section of the SNS. Specifically, the two ARMs were placed adjacent to Faraday Cup 334, which is between drift tube linac (DTL) 3 and DTL 4. The ARMs were placed at a distance of approximately 6.5 feet from the faraday cup. The location of the ARMs is shown in Figure 7. This comparison was performed on March 15, 2022. For the comparison, the beam was accelerated to 1 GeV, for a total power of 1.4 MW, and a repetition rate of 1 Hz. Faraday Cup 334 was inserted into the beam during the test to create higher than usual radiation levels in the linac tunnel. The Chipmunk QF was set to 2.5, while the Far West QF was set to 3.

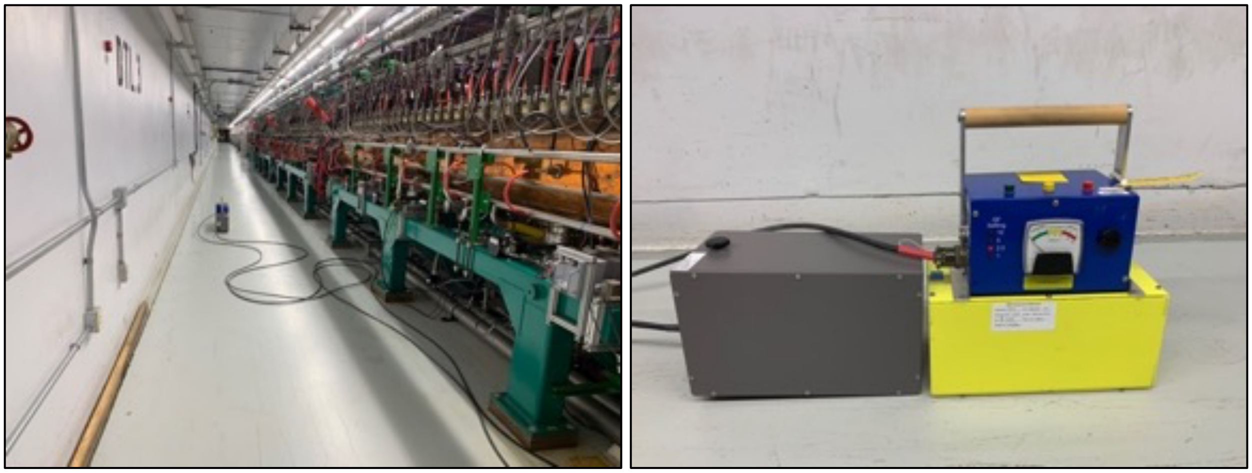

Figure 7: ARM Placement in SNS Warm Linac

Figure 8 plots three sets of data from the warm linac comparison. The first data set is the Chipmunk 10 second rolling average dose rate signal. The second data set is the Far West instantaneous dose rate signal. The third data set is the Far West high alarm signal, which is either a 1 (alarm signal being sent) or 0. For this test, the alarm was set to ≥ 100 mrem/hour.

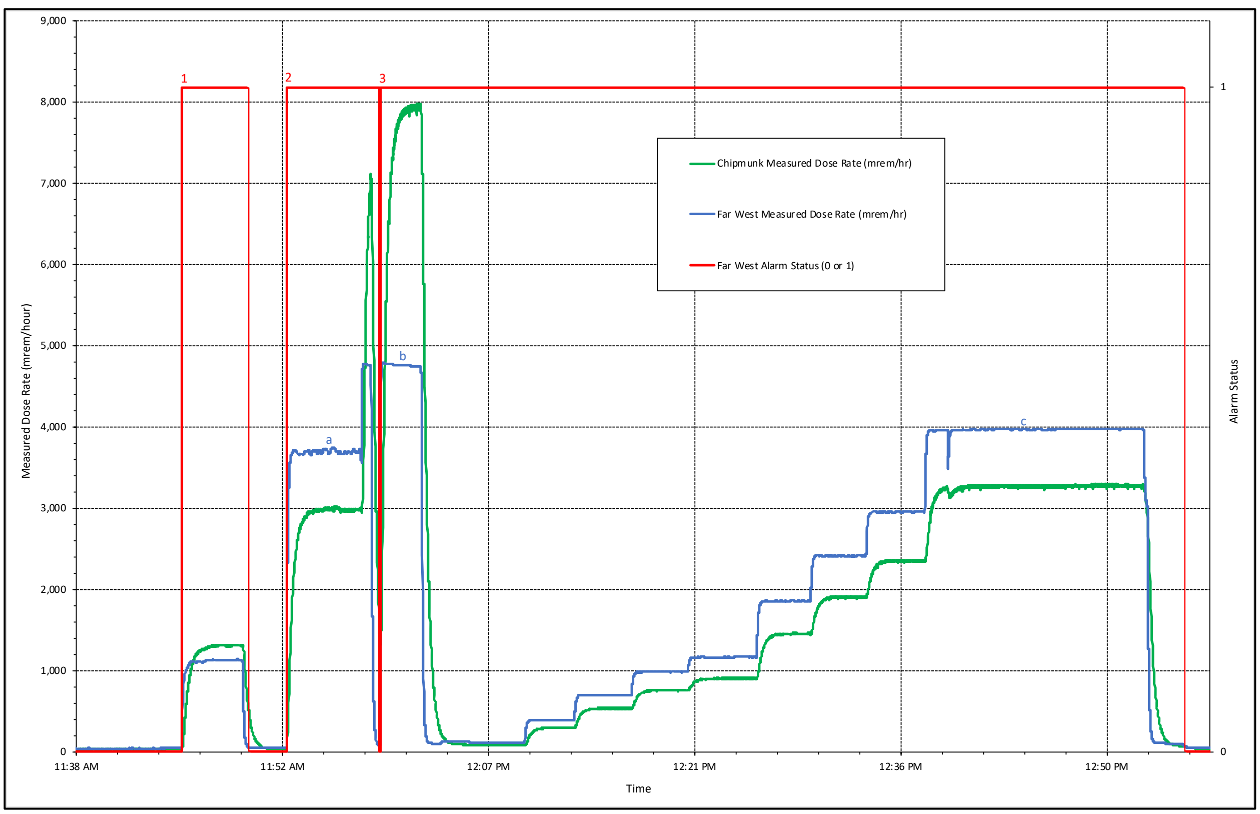

Figure 8: Chipmunk and Far West Comparision in Warm Linac

The purpose for presenting this data is to compare the Far West and Chipmunk response to a pulsed radiation field. This data is also used to show how the Far West alarm signal responds to a pulsed radiation field. It is worth noting that these data are taken from a archiver function within the SNS control software, EPICS, and thus the time and date stamp is not exact. Nonetheless, these data can be used to arrive at conclusions about their comparative response.

The data provided in Figure 8 shows that the Chipmunk and Far West respond differently to the same radiation field, which corroborates one of the conclusions from the previous comparision study (presented in Figures 4, 5, and 6). In an intense, pulsed gamma and neutron radiation field, the Far West detector appears to saturate at a dose rate between approximately 3.7 rem/hour to 4.7 rem/hour.

At point “a” in Figure 8, the Far West response reaches approximately 3.7 rem/hour, while the Chipmunk response asmytotically approaches a much lower dose rate, only 3 rem/hour. At point “b” the opposite is true. The Far West response is only approximately 4.7 rem/hour, but the Chipmunk appears to level off at approximately 7.9 rem/hour. It is worth noting that at point “a” both the radio frequence (RF) to the DTLs is in phase and there is no Hydrogen ion beam running through the linac. At point “b” the RF to the DTLs is in phase and there is Hydrogen ion beam running through the linac. Thus, the Far West and Chipmunk respond differently to these two conditions.

At point “c” there is beam on and it is being sent to the accumulator ring for 50 turns. The Chipmunk asmytotically reaches a level of approximately 3.25 rem/hour, while the Far West reaches approximately 3.95 rem/hour.

There are many factors that are contributing to the different responses shown in Figure 8. For the purpose of this USIE, it is sufficient to show that the Far West can detect radiation fields in excess of 1,000 mrem/hour, which, as stated previously in this document, is the maximum dose rate at which the manufacturer guarantees accuracy [11].

What is of paramount importance to this discussion is the response of the Far West alarm condition to a pulsed radiation field. The three numbers on Figure 8 will be used to elucidate this discussion. Each number corresponds to a point where the alarm relay was closed (0), but then is opened (1) due to a significant, quick rise in the radiation field. To help illustrate how quickly the radiation field increases, at point “2” the radiation field goes from approximately 45 mrem/hour to over 3,000 mrem/hour in approximately 8 seconds.

At point “1” the Far West dose rate was > 100 mrem/hour at 11:45:44. The alarm status switched from 0 to 1 at 11:45:45, which is a response time of approximately one second.

At point “2” the Far West dose rate was > 100 mrem/hour at 11:53:03. The alarm status switched from 0 to 1 at 11:53:05, which is a response time of approximately two seconds.

At point “3” the Far West dose rate was > 100 mrem/hour at 11:59:36. The alarm status switched from 0 to 1 at 11:59:38, which is a response time of approximately two seconds.

The data presented in Figure 8 shows two things. 1) The Far West alarm trip responds on average approximately one to two seconds after the dose rate signal increases above the alarm setpoint of 100 mrem/hour. 2) The alarm status is persistent in high, pulsed radiation fields (up to approximately 8 rem/hour), and shows no improper response characteristics.

III. Does the proposed activity or discovered condition affect information presented in the FSAD-NF or FSAD-PF, e.g., regarding equipment, administrative controls, or safety analyses. If so specify the applicable FSAD and relevant sections.

No. Both the FSAD-PF [1] and the Final Safety Assessment Document for Neutron Facilities (FSAD-NF) [13] have language that allow either Chipmunks or approved equivalent ARMs as PPS IRMs.

IV. Does the proposed activity or discovered condition affect any of the requirements of the ASE. If so, list the affected sections.

No. Section 3.2 of the Accelerator Safety Envelope (ASE) [12] discusses the credited functions of the PPS. The third credited function of the PPS is to "shut off beam if radiation levels set by the SNS RSO are reached at PPS interlocked area radiation monitor locations." The wording of this credited function does not specify the make and model of the PPS IRM.

V. USI Evaluation Criteria:

1. Could the change significantly increase the probability of occurrence of an accident previously evaluated in the FSADs?
   Yes __ No _X_
   Justification:

A change to a credited engineered control (CEC) does not affect the unmitigated probability of accidents evaluated in the FSADs. Therefore, the use of Far Wests as PPS IRMs does not significantly increase the probability of occurrence of an accident previously evaluated in the FSADs.

2. Could the change significantly increase the consequences of an accident previously evaluated in the FSADs?
   Yes __ No _X_
   Justification:

A change to a CEC does not affect the unmitigated consequence of accidents evaluated in the FSADs. Therefore, the use of Far Wests as PPS IRMs does not significantly increase the consequences of an accident previously evaluated in the FSADs.

3. Could the change significantly increase the probability of occurrence of a malfunction of equipment important to safety previously evaluated in the FSADs?
   Yes __ No _X_
   Justification:

The use of Far West ARMs as PPS IRMs provides a reliable alternative to Chipmunks. They are very similar in principle of operation and are a fail-safe design. Furthermore, Far Wests are readily available for purchase to replace dwindling supplies of Chipmunks. The fail-safe features of the Far Wests ensure an equivalent level of reliability as the Chipmunks. Instrument failure becomes more likely with age, thus replacing the aging Chipmunks with newer Far West will most likely reduce the probability of an equipment malfunction important to safety. Far West ARMs have been used at Brookhaven National Laboratory's (BNL) National Synchrotron Light Source II (NSLS-II) for multiple years, and have proven to be a reliable technology there. Furthermore, Far Wests have been used at the SNS (Beam Test Facility (BTF), Service Gallery Radiation Alarm System (SGRAS), and at multiple instrument beam lines) for years in a non-credited fashion with a high degree of reliability. Thus, the use of Far West ARMs as PPS IRMs does not significantly increase the probability of occurrence of a malfunction of equipment important to safety previously evaluated in the FSADs.

4. Could the change significantly increase the consequences of a malfunction of equipment important to safety previously evaluated in the FSADs?
   Yes __ No _X_
   Justification:

It is assumed that a malfunction of equipment important to safety provides no mitigation for associated accidents. Therefore, full unmitigated accident consequences are assumed for a CEC malfunction. Since the use of Far West ARMs as credited PPS IRMs does not have an impact on the unmitigated consequences of associated accidents, the change proposed in this USIE does not significantly increase the consequences of a malfunction of equipment important to safety previously evaluated in the FSADs.

5. Could the change create the possibility of a different type of accident than any previously evaluated in the FSADs that would have potentially significant safety consequences?
   Yes __ No _X_
   Justification:

The use of Far West ARMs as credited PPS IRMs does not introduce any new hazards or accident initiators. Therefore, the change proposed in this USIE does not create the possibility of a different type of accident than any previously evaluated in the FSADs.

6. Could the change increase the possibility of a different type of malfunction of equipment important to safety than any previously evaluated in the FSADs?
   Yes __ No _X_
   Justification:

Like the Chipmunk, the Far West is a fail-safe ARM design. Furthermore, the Far West has been in use at both SNS (in a non-credited fashion) and at BNL's NSLS-II for multiple years. Thus, the design is considered mature and has been field tested. To add to this, the Far West and Chipmunk comparison presented in this USIE directly shows that the Far West is suited for use in the high-intensity, pulsed radiation fields produced by the SNS proton beam. It is fully expected that once introduced as PPS IRMs, Far West ARMs will go through a quarterly certification process in accordance with SNS-Operations Procedures Manual (OPM) 2.H-18.7 [14]. The quarterly certification will ensure all credited Far Wests are performing as expected. The Far Wests will also be taken to the RICL at ORNL once a year for calibration. Because of the reasons presented in this paragraph, it is judged that the introduction of Far Wests as PPS IRMs will not increase the possibility of a different type of malfunction of equipment important to safety than any previously evaluated in the FSADs.

VI. USI Determination: A USI is determined to exist if the answer to any of the 6 questions above (Section V) is "Yes." If the answer to all 6 questions is "No", then no USI exists.

a. Does the proposed activity (or discovered condition) constitute a USI?
   ___ Yes – DOE approval required prior to implementing.
   _X_ No – Proposed activity may be implemented with appropriate internal review.

Thomas Copinger Digitally signed by Thomas Copinger
Date: 2023.09.08 10:24:15 -04'00'

Thomas Copinger, Senior Accel. Fac. Safety Engr, Qualified Preparer Date

Kelly Mahoney Digitally signed by Kelly Mahoney
Date: 2023.09.11 14:18:30 -04'00'

Kelly Mahoney, Protection Systems Group Lead Date

Christi Elam Digitally signed by Christi Elam
Date: 2023.09.19 14:18:33 -04'00'

Christ Elam, SNS Radiation Safety Officer Date

Jacob Platfoot Digitally signed by Jacob Platfoot
Date: 2023.09.19 14:49:00 -04'00'

Jacob Platfoot, Accelerator Safety Program Lead, Qualified Reviewer Date

Approvals:

Fulvia C. Pilat Digitally signed by Fulvia C. Pilat
Date: 2023.09.20 15:49:16 -04'00'

Signature of SNS Operations Manager or Designee Date

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