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Memo

Date: *July 15, 2014*

To: *RSC, D. Phillips, and D. Kayran*

From: *D. Beavis*

Subject: *ERL Chipmunk Locations*

Introduction

This memorandum provides the logic that was used to locate the chipmunks at ERL. There are presently a total of eleven chipmunks at ERL. The chipmunks were installed with extra cable length so that their locations could be adjusted during beam fault studies. The chipmunks are listed in the Table below along with their interlock and alarm thresholds.

CHIPMUNKS			
Name	Location	Interlock [mrem/hr]	Alarm [mrem/hr]
NMO170	North Labyrinth	20	10
NMO171	North Gate	2.5	1
NMO172	1 MW Waveguide port	2.5	1
NMO173	50 kW Waveguide area	2.5	1
NMO174	West cryo pipe exit	2.5	1
NMO175	South Gate	2.5	1
NMO176	South Labyrinth	50	20
NMO177	x-ray Detector 1	-	-
NMO178	x-ray detector 2	-	-
NMO181	Gun power limit	20	10
NMO182	Power limit gun and dump	20	10

The two labyrinth chipmunks, **NMO170 and NMO176**, have been moved to be sensitive to albedo off the end walls of the facility. The interlock and alarm levels have been increased so they will not be too limiting for initial low power testing. After low power testing they may be returned to their initial locations in the corner of the labyrinths or other suitable locations. They are on moving mechanisms so that they can be easily moved to change their sensitivity to the albedo for the nearby wall.

NM0170 prime purpose was to protect areas on the northwest area from faults in the ring and low energy transport. NMO176 was located to protect the south and west walls from faults in the ring with beam headed towards the south.

NMO177 and NMO178 are chipmunks that have been provided for the experimenter to obtain radiations measurements inside the shielding. During the shielding fault studies these may also be used to characterize the radiation levels inside. These two chipmunks have long cables so that they can be moved almost anywhere inside the facility. The dose rate is recorded in the chipmunk viewer database so that the information can be retrieved. There are no alarm or interlock levels associated with these two chipmunks. The experimenter is allowed to move these as desired except if being specifically used for a beam fault study.

NMO181 and NMO182 were placed inside the shielding to help limit the beam power during initial low power testing. Each is presently shielded with 1 foot of light concrete to reduce the sensitivity to beam losses to levels that should allow for low power testing. The shielding and interlock/alarm levels will be adjusted as the low power testing is conducted. It is intended that these will remain in the shielding or be move during initial commissioning of the facility at 3.5 MeV. They are presently intended as temporary devices but depending on the fault study results can be added as permanent interlocking radiation monitors. If these chipmunks are left inside the goal would be from them to prevent beam losses anywhere to less than 1kW and perhaps as low as 100 Watts.

NMO171 and NMO175 monitor the dose rates at the personnel gates. The gates are expected to be areas where personnel may gather while the machine operates, waiting for a quick access.

NMO172 and NMO173 monitors penetrations on the east wall near the utility building. NMO172 is directly outside the 1 MW waveguide port. NMO173 is directly outside the buss block that is used to route cables into the blockhouse.

MNO174 monitors the cryo pipe vent on the west side of the ERL blockhouse. This location provides protection for losses that could irradiate many of the weak locations on the west wall and also the east wall.

Most chipmunk locations were chosen to limit the beam faults for ERL operating at 25 MeV with the ring. The machine can also operate with beam from the gun to the beam dump with the five-cell cavity not operating. This is the commissioning plan will have the machine start with gun to dump operations.

Chipmunk Sensitivity for Gun to Dump Operations

Previous documents often examined dose rates due to beam losses for the 25 MeV beam operating in the ring. This section will provide some information on the chipmunk sensitivity to beam losses in the gun to dump operations. Initial testing will be conducted at low power and systematically increased in power as the credited controls are verified to provide adequate protection. If the protection appears insufficient for increasing the beam power for operations then higher power operations will not occur until the credited controls are upgraded and verified to be adequate. The table below provides examples of loss locations and the dose rate expected at a particular chipmunk along with the interlock level and the continuous power loss for the interlock level.

Chipmunk Dose Rate for Selected Beam Faults at 3.5 MeV for 1 kW Losses

Name	Location	Interlock [mrem/hr]	Fault Dose Rate [mrem/hr]	Loss Limits (W)	Comment/reference
NMO170	North Labyrinth (present location)	20	90,000	0.2	If loss at dipole for north ring
NMO170	North Labyrinth (present location)	20	23,000	0.9	If loss an end of five cell cavity
NMO170	North Labyrinth (present location)	20	4,000[1]	5	If loss at end of gun
NMO170	North Labyrinth (moved back to corner)	20	1,400	14	If loss at dipole for north ring
NMO170	North Labyrinth (moved back to corner)	20	350	58	If loss an end of five cell cavity
NMO170	North Labyrinth (moved back to corner)	20	60	333	If loss at end of gun
NMO171	North Gate	2.5	0.5 or lower	5,000	Only effective for higher losses
NMO171	North Gate	2.5	130[2]	20	If located on opposite wall—loss at extraction dipole
NMO172	1 MW Waveguide port	2.5	0.025[3]	10,000	Fault near halo scraper
NMO173	50 kW Waveguide area	2.5	7[4]	625	Fault before five cell cavity
NMO174	West cryo pipe exit	2.5	100	25	At building wall
NMO175	South Gate	2.5	4[5]	625	Through wall with fault near laser port
NMO176	South Labyrinth	50	10,000[6]	5	Fault at end flange
NMO176	South Labyrinth	50	4,000	12.5	Last extraction dipole
NMO176	South Labyrinth in corner	50	7	7,000	Fault at end flange
NMO181	Gun power limit	20	25,000[7]	0.8	Flange location.
NMO181	Gun power limit	20	8,000[8]	2.5	At last extraction dipole
NMO182	Power limit gun and dump	20	11,000	2	Flange location
NMO182	Power limit gun and dump	20	44,000	0.5	First extraction dipole

[1] The location was chosen so that this chipmunk would limit the beam to about 10 W of loss at the upstream end of the machine.
[2] Based on the gammas through the cable port and having one reflection to get to the chipmunk.
[3] The 50 mrads/hr at 1 mW was reduced by a factor of two for the distance to the chipmunk.
[4] Simple scaling of the 25 MeV transverse beam result.
[5] The actual number is expected to be lower. The gun structure provides shielding and a conservative backward dose rate of 10^4 rads-m^2/(kW) has been used along with 60 gm/cm^3 as the TVL for light concrete.
[6] Same comments as in footnote 5. Expect a 10 W loss to be more like 10 mrads/hr
[7] Location was chosen to limit 2.5 MeV beam losses to 10 Watts.
[8] Location was chosen to limit 2.5 MeV beam losses to 10 Watts.

The present layout of chipmunks can interlock and limit losses to less than 100 Watts along the low energy transport.

The beam dump shielding is relatively thin. Additional shielding can be added around the beam dump as the beam power increases. For example 1 kW of 3.5 MeV beam into the beam dump will register 800 mrads/hr at NMO180. With NMO170 in its current position it will register 600 mrads/hr. If NMO170 is moved to the original position in the corner of the labyrinth then 1 kW would produce 5 mrads/hr at chipmunk NMO170. It is clear the changes to the chipmunk positions or the beam dump shielding will be required to get to high power operations.

It should be noted that many of the estimates produced here use “rough” approximations. They should not be considered very accurate, but accurate enough to allow safe fault studies to determine the sensitivity of the chipmunks to various fault locations.

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