SLAC Memorandum **Date:** June 1, 2005

To: Sayed Rokni

From: H. Y. Khater

Subject: Analysis of the New L-band RF Penetration in the NLCTA Roof

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The ILC group requested adding a new penetration to the roof of the NLCTA [1]. The new penetration will be used for L-band RF waveguide. The standard waveguide size is 6.5” x 3.25” but the associated flanges require an 11”-diameter hole. Figure 1 shows an elevation view indicating the position of the new penetration relative to the NLCTA beamline. The waveguide will be connected to L-band structure located in the high energy region of the NLCTA beamline The level of radiation streaming through the penetration was analyzed for the nominal and safety envelop beam powers previously analyzed [2] and included in the NLCTA safety Assessment Document (SAD) [3]. In addition to radiation streaming through the penetrations, direct dose rates are also calculated on the top of the 4’-thick concrete.

In order to calculate the dose rates outside the penetration, a Monte Carlo simulation was performed using the MCNPX code [4]. The MCNPX code was run with incident electron kinetic energy of 1.1 GeV, and with electron cutoff energy of 1 MeV. The kinetic energy represents the highest possible energy included in the NLCTA SAD. The beam was assumed to hit a 12”-long cylindrical copper target which has a 2” radius. Results obtained for the maximum energy and power (5747 W) specified by the SAD (safety envelop for upgraded power level) were scaled for power levels specified for nominal operation (438 and 1451 W) as well as the safety envelop design power level (3233 W). Figure 2 shows the MCNPX model used in the calculation. In this figure, the inside of the NLCTA enclosure is shown in light blue, the enclosure concrete walls in light green, penetration in dark green, scoring region in yellow. In addition, the beam line is shown in dark blue. Finally, the two circles shown in blue are not part of the geometry and only represent DXTRAN spheres (for MCNPX variance reduction).

Calculations were performed for two penetration options. The first option (Option I) represents the requested 11”-diameter hole. On the other hand, the second option (Option II) assumes that the roof hole matches the actual size of the wave guide size (6.5” x 3.25”). Finally, dose rates resulting form radiation streaming through the penetrations were compared to direct dose rates on top of the 4’-thick concrete roof. The direct dose rates were calculated by using the SHIELD11 code [5].

Table I shows a comparison between the dose rates resulting form radiation streaming through the penetrations and the direct dose rates on top of the 4’-thick concrete roof for Option I. Since the full body is not exposed to the streaming radiation through the hole, the calculated effective dose equivalent values are reduced by a factor of 4. As shown in the table, the dose rates caused by radiation streaming through the penetration are higher than the direct dose rates on the roof. The dose rates on the top of the penetration, at nominal power levels, which are caused by normal beam loss (0.5% loss at a point) or mis-steering beam losses (100% loss at a point), exceeds the maximum dose rates on top of the 4’-thick concrete roof by ~ factor of 5 or 6. On the other hand, 100% beam losses of the power levels identified by the safety envelop produced dose rates which are factor of 5 higher for the penetration case. The dose rates caused by neutron streaming through the penetration are more than twice the dose rate caused by photon streaming.

Table II shows a comparison between the dose rates resulting form radiation streaming through the penetrations and the direct dose rates on top of the 4'-thick concrete roof for Option II. As shown in the table, the dose rates caused by radiation streaming through the penetration are somewhat higher than the direct dose rates on the roof for the nominal power levels. On the other hand, the dose rates above the penetration are lower than the direct dose rates above the concrete for the safety envelop power levels. In this case, the dose rates caused by photon streaming through the penetration are twice the dose rate caused by neutron streaming. Comparing dose rates results from Tables I and II shows that using Option II penetration (RF waveguide size) results in a reduction of radiation streaming through the penetration by about factor of 5. The reduction is due to a drop in photon and neutron dose rates by factors of 2 and 10, respectively.

Summary

Adding the new penetration to the roof of the NLCTA may proceed under the following conditions:

1. The space between the 11"-diameter hole and the RF waveguide is filled with gravel (option II).
2. The penetration is blocked when not in use.
3. Proper RSWCF is issued.

References

[1]. S. Doebert, "Evaluation of New Penetration into the NLCTA Housing," Memo to Hesham Khater, March 23, 2005.

[2]. V. Vylet and T. Lavine, "Radiation Protection in the NLCTA," NLCTA-Note # 46.2, January 8, 1996.

[3]. SLAC Technical Division, "Safety Assessment Document – Next Linear Collider Test Accelerator," April 24, 1996.

[4]. L. Walters (Ed.), "Monte Carlo N-Particle Transport Code System for Multiparticle and High Energy Applications, Version 2.5.f, LANL, 2005.

[5]. W. Nelson and T. Jenkins, "The SHIELD11 Computer Code," SLAC-R-737, February 2005.

Cc: S. Doebert, K. Jobe, M. Ross, T. Raubenheimer, F. Asiri, H. Vincke, RP file.

Table I. Summary of dose rates (mrem/hr) on top of the NLCTA roof (option I).

Parameter	**Nominal**		**Safety Envelop**	
	Design	**Upgrade**	**Design**	**Upgrade**
Power (W)	438	1451	3233	5747
Energy (MeV)	480	796	600	1066
Normal Dose Rate Outside 4'-thick Concrete Roof (mrem/h)[1]	0.6	2.8	1043	2806
Normal Dose Rate on Top of the Roof Penetration (mrem/h)[1,2]	4.6	15.2	6665	11845
Mis-steering Dose Rate Outside 4'-thick Concrete Roof (mrem/h)[3]	114	568	1043	2806
Mis-steering Dose Rate on Top of the Roof Penetration (mrem/h)[2,3]	920	2990	6665	11845

[1] **Normal loss at a point is 0.5% for nominal and 100% for safety envelop.**
[2] **Effective dose equivalent values are reduced by a factor of 4.**
[3] **Mis-steering loss at a point is 100% for nominal and safety envelop.**

Table II. Summary of dose rates (mrem/hr) on top of the NLCTA roof (option II).

Parameter	Nominal		Safety Envelop	
	Design	Upgrade	Design	Upgrade
Power (W)	438	1451	3233	5747
Energy (MeV)	480	796	600	1066
Normal Dose Rate Outside 4'-thick Concrete Roof (mrem/h)[1]	0.6	2.8	1043	2806
Normal Dose Rate on Top of the Roof Penetration (mrem/h)[1,2]	1	3.3	1449	2575
Mis-steering Dose Rate Outside 4'-thick Concrete Roof (mrem/h)[3]	114	568	1043	2806
Mis-steering Dose Rate on Top of the Roof Penetration (mrem/h)[2,3]	200	650	1449	2575

[1] **Normal loss at a point is 0.5% for nominal and 100% for safety envelop.**
[2] **Effective dose equivalent values are reduced by a factor of 4.**
[3] **Mis-steering loss at a point is 100% for nominal and safety envelop.**

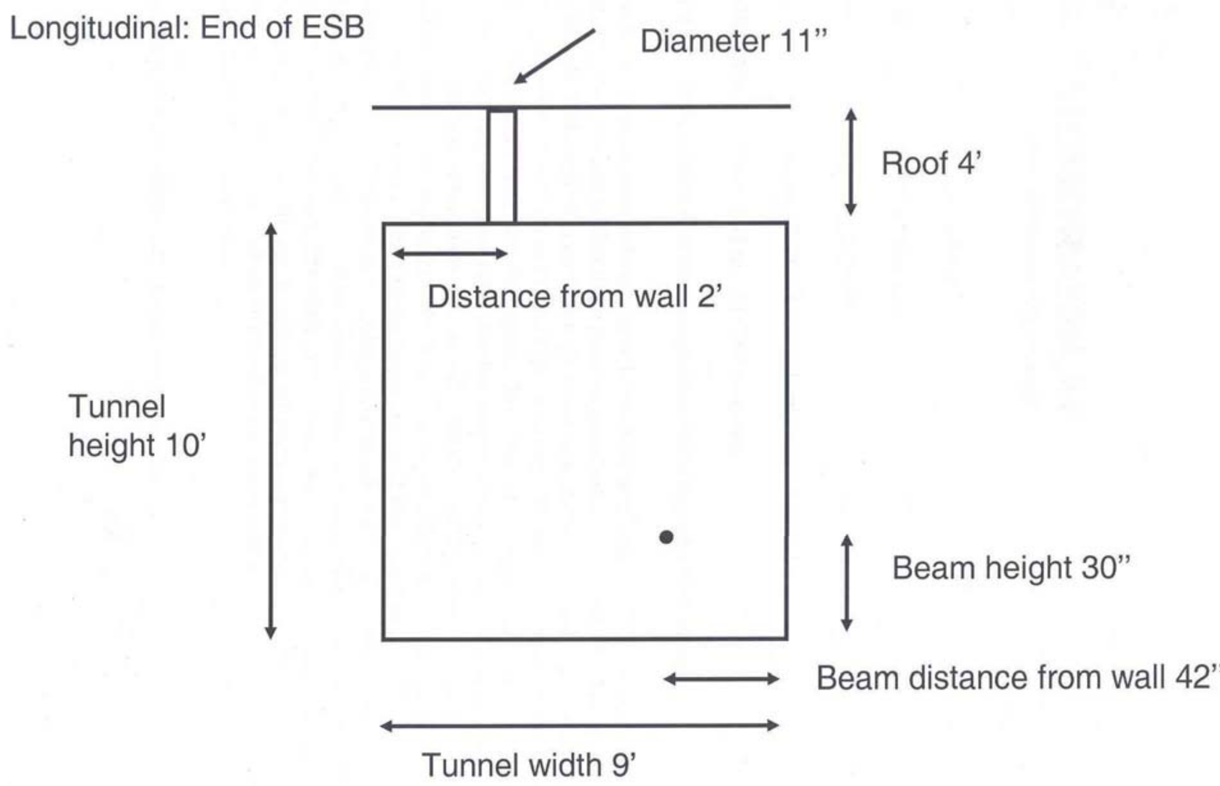

Fig. 1. Elevation view of the NLCTA roof penetrations.

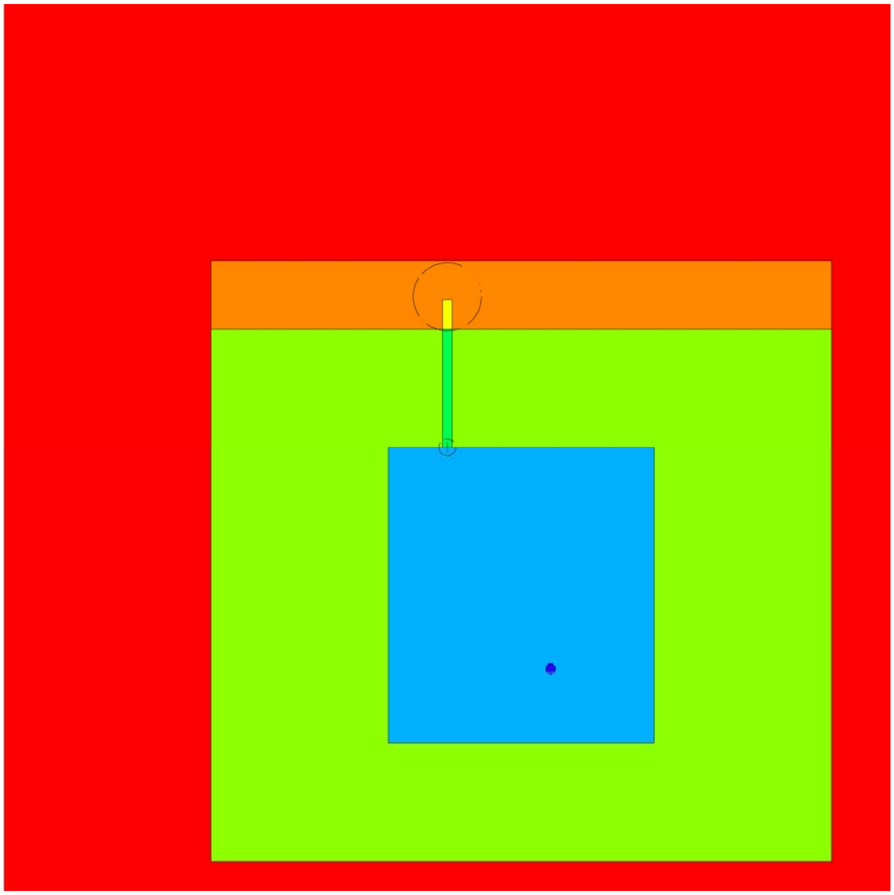

Fig. 2. Elevation view of MCNPX model.