Los Alamos
NATIONAL LABORATORY

memorandum

LANSCE Division
Group LANSCE-1

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SUBJECT: Refrigeration Cost Estimates for a Superconducting High Energy Linac for SNS - Addenda

During the course of developing a superconducting option for SNS, the question of the impact of increasing cavity gradient to 110%, or even to 120% of the specified gradient on the cryosystem costs has been raised. Using the tools described in [1], this impact has been evaluated. Attached are two graphs for Strawman #1 and Strawman #2 that give low and high estimates for the cryosystem costs (refrigerator + distribution system) as functions of duty factor and of cavity gradient. In developing these graphs, the cavity heat load is assumed to scale as the square of the cavity gradient. The difference between the static and dynamic coupler loads was also assumed to scale with the square of the gradient. This assumption for the coupler is an over simplification of the problem, but the impact is dwarfed by the impact of varying the gradient on the cavity heat loads.

The yearly estimated electrical and liquid nitrogen costs for the cryosystem as functions of duty factor and gradient are given in the tables below, as are the estimated equivalent 4.5 K heat loads.

Strawman #1

Table 1: Estimate Equivalent 4.5 K Heat Loads for Strawman #1

Duty Factor %	@ Specified Gradient Watts	@ 1.1 X the Specified Gradient Watts	@ 1.2 X the Specified Gradient Watts
7%	5000	5400	5900
8%	5300	5800	6300
9%	5600	6200	6800
10%	5900	6500	7200
11%	6200	6900	7600
12%	6500	7300	8100

Table 2: Yearly Liquid Nitrogen Costs for Strawman #1 @ $0.07/L

Duty Factor %	@ Specified Gradient $	@ 1.1 X the Specified Gradient $	@ 1.2 X the Specified Gradient $
7%	214 K	232 K	252 K
8%	227 K	248 K	270 K
9%	240 K	263 K	289 K
10%	253 K	278 K	307 K
11%	265 K	294 K	325 K
12%	278 K	309 K	343 K

Table 3: Yearly Electrical Costs for Strawman #1 @ $0.05/kW-hr

Duty Factor %	@ Specified Gradient $	@ 1.1 X the Specified Gradient $	@ 1.2 X the Specified Gradient $
7%	649 K	704 K	764 K
8%	688 K	751 K	820 K
9%	727 K	797 K	875 K
10%	766 K	844 K	930 K
11%	804 K	891 K	986 K
12%	843K	938 K	1040 K

Strawman #2

Table 4: Estimate Equivalent 4.5 K Heat Loads for Strawman #2

Duty Factor %	@ Specified Gradient Watts	@ 1.1 X the Specified Gradient Watts	@ 1.2 X the Specified Gradient Watts
7%	5700	6200	6700
8%	6000	6600	7100
9%	6400	6900	7600
10%	6700	7300	8000
11%	7000	7700	8500
12%	7300	8100	8900

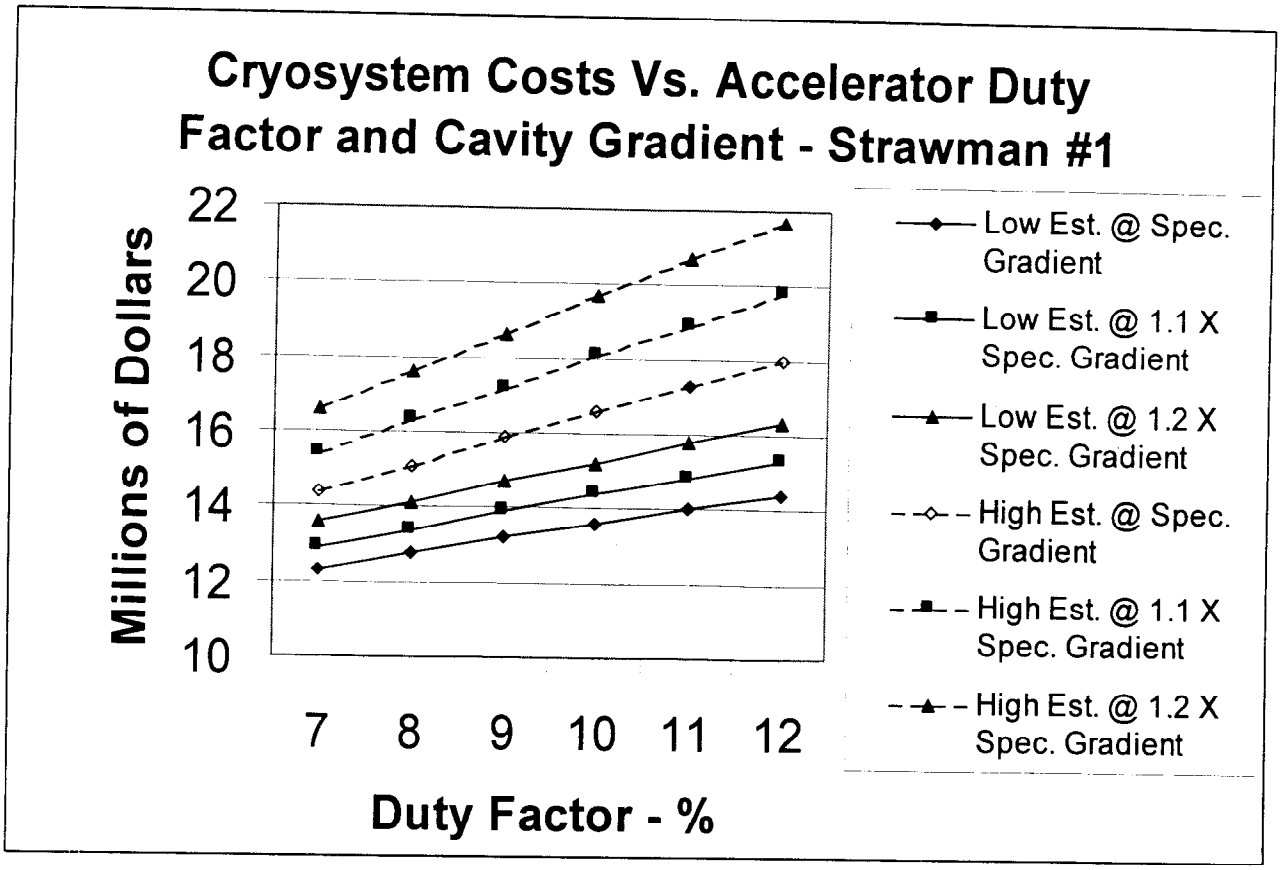
Table 5: Yearly Liquid Nitrogen Costs for Strawman #2 @ $0.07/L

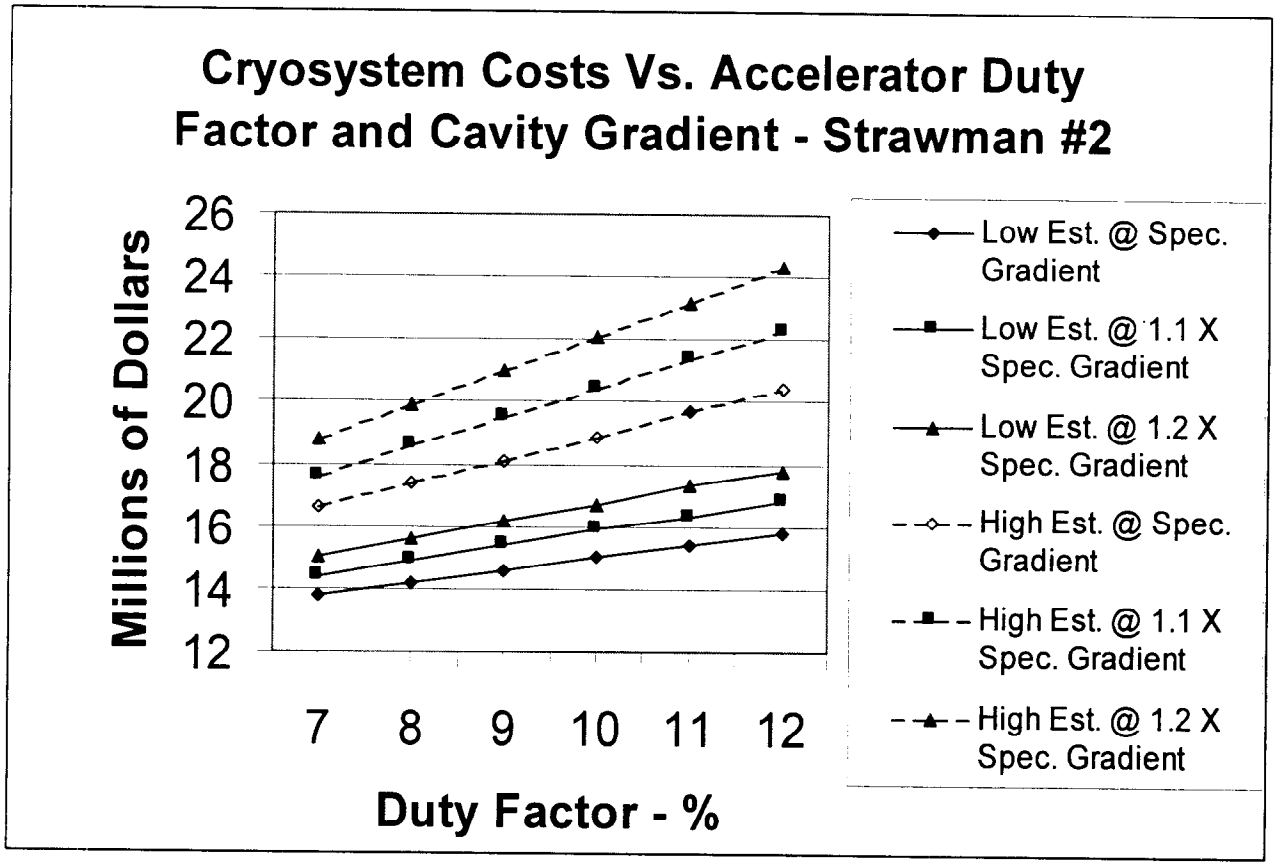
Duty Factor %	@ Specified Gradient $	@ 1.1 X the Specified Gradient $	@ 1.2 X the Specified Gradient $
7%	245 K	263 K	284 K
8%	259 K	280 K	304 K
9%	272K	296 K	323 K
10%	285 K	312 K	342 K
11%	299 K	329 K	361 K
12%	312 K	345 K	381 K

Table 6: Yearly Electrical Costs for Strawman #2 @ $0.05/kW-hr

Duty Factor %	@ Specified Gradient $	@ 1.1 X the Specified Gradient $	@ 1.2 X the Specified Gradient $
7%	740 K	798 K	862 K
8%	781 K	848 K	921 K
9%	822 K	897 K	979 K
10%	863 K	947 K	1040 K
11%	905 K	997 K	1100 K
12%	946 K	1050 K	1160 K

1. *Refrigeration Cost Estimaes for a Superconducting High Energy Linac for SNS*, J. Patrick Kelley, LANSCE-1:99-080, April 27, 1999.


Cryosystem Costs Vs. Accelerator Duty Factor and Cavity Gradient - Strawman #1
Millions of Dollars
22
20
18
16
14
12
10
7
8
9
10
11
12
Duty Factor - %
Low Est. @ Spec. Gradient
Low Est. @ 1.1 X Spec. Gradient
Low Est. @ 1.2 X Spec. Gradient
High Est. @ Spec. Gradient
High Est. @ 1.1 X Spec. Gradient
High Est. @ 1.2 X Spec. Gradient


Cryosystem Costs Vs. Accelerator Duty Factor and Cavity Gradient - Strawman #2
Millions of Dollars
26
24
22
20
18
16
14
12
7
8
9
10
11
12
Duty Factor - %
Low Est. @ Spec. Gradient
Low Est. @ 1.1 X Spec. Gradient
Low Est. @ 1.2 X Spec. Gradient
High Est. @ Spec. Gradient
High Est. @ 1.1 X Spec. Gradient
High Est. @ 1.2 X Spec. Gradient