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Transport Efficiency and Target SEC Calibrations for SEB Beam Lines

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SEB Transport Efficiencies and Switchyard Losses

Study Period(s): January 17 & 26, & April 14 , 1995

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Introduction:

Based on studies done in last years SEB run a series of new studies were performed in order to try to understand the questions raised from last years data.[1] In particular more data was needed to understand how the target SEC's respond based on where they were being hit with the beam. Also, there are two separate questions relating to calibrating loss monitors in the switchyard. First, could the SEC's and losses be calibrated in the same manner that the SEB extraction efficiency is calibrated ?, in which a local point loss is created by making the extraction septum thicker (by skewing it) giving a linear curve of Inefficiency versus Efficiency. Secondly, do loss monitor calibrations change based on the geometry of the loss. In particular, we wondered if beam lost on one side of a lambertson septum would give a significantly different answer than beam lost on the other side. Certainly if this effect is large it would introduce a large uncertainty into efficiencies observed from the loss monitors.

The Studies :

Beam was transported cleanly down the individual beam lines. For B and C the emittance of the extracted beam was unchanged for the January study but was reduced by 1/2 for the April study. For A and D the emittance (horizontal) was reduced by approximately 1/2 in both studies. A test of beam transported down C line with the smaller emittance was done in January and proved to produce the same magnitude losses (and distribution) as the normal emittance case. Data taken consisted mostly of CLYDE 10 pulse averages saved into files on the PDP10. As intermediate intensity monitors the area of the profiles on the EPM's at C155 (in front of CD2&3) and D241 (downstream of DD14) were integrated using a Lecroy 9404 digital oscilloscope. These proved to be excellent intensity monitors under the conditions of the studies.

Careful horizontal and vertical scans of the target SEC's were done. The C and B SEC's didn't show any position dependence during the January studies but in April, C showed a strong position dependence. What exists for the C data in January is beam 'on target' and 'off target' which shows no change in response, even when the difference between the C10SEC and CSEC is plotted versus the switchyard losses (which amplifies the effect by showing the change in the difference for the same distribution of losses). This is in contrast to last years data which showed approximately a 5 % effect. The response in April showed a 15 % effect.

For each beam line the lambertson septums were 'parked' next to the beam and then skewed into the beam to create a point loss. From these scans a significant amount of information can be derived. This portion of the data is still being digested, although some very interesting results are presented in this report.

Preliminary Observations:

A number of errors were corrected in the CLYDE software prior to the studies, which had caused some unusual results in last years studies. All the calibration constants which were in when we shutdown last year were used in these studies, and no constants have been changed (except in the case where capacitors were changed on loss monitor integrators to prevent saturation in certain areas). This alone is a significant statement since we are running with lower switchyard losses and the sum of the target SEC's is higher relative to the internal intensity than last year. Last year we had difficulty running with better than 15 (% ?) on the Normalized sum of the switchyard long losses and with T/I greater than 80 % (T/I is the sum of the target SEC's divided by the intensity in the AGS just before extraction). This year the comparable numbers are 9 % on the long losses and T/I typically between 85 and 90 %. Although the evidence is indirect it seems we can attribute the better performance to the use of the AGS VHF cavity during the period between transition and extraction. It has been observed that switchyard losses (extraction losses as well) are highly dependent on how well the last VHF pulse 'dilutes' the beam.

There still exists a 'logic' error in the calculations done in CLYDE. This is in how CLYDE subtracts the backscattering from targets seen on loss monitors just upstream of the target from a loss monitor that sits just below the target. The problem is such that the subtraction is only good for a small range of intensities.

Analysis :

Attached are eight figures showing position scans for the A, B5, C, and D SEC's. The A and D scans were done in January, the B5 scan was done February 27 and the C scan was done April 7. They basically show that the work function on the SEC has been changed significantly on the spot most often hit by the beam. The B5 SEC shows the opposite effect, which is presently not explained. The horizontal axis on each of these is in units of mm for the position of the beam on the SEC. These are only approximate. They were derived from the position changes as seen on multiwires that are within a few feet of the SEC's.

The method used to calibrate loss monitors and SEC's consisted of changing the amount of loss between two intensity measurements, one calibrated and one not calibrated, and plotting the ratio of the loss to initial intensity to the ratio of the measured intensities. This is the same technique used to calibrate the extraction efficiency. The method assumes the beam being lost does not change in geometry with the loss mechanism.

Table 1 shows the SEC Calibrations that are predicted based on assuming the percentage losses shown on CLYDE are more or less correct (with a +/- 50 % uncertainty).

This is the traditional method for calibrating the SEC's. Since the uncertainty in the transport losses is large the transport losses have to be brought to an absolute minimum to ensure the calibration on the SEC's is accurate.

Table 1: SEC Calibration Multiplying Factors, Traditional Method

Beam Line	XCBM TP	Extract Losses, %	Transport Loss %	Predicted to Target (SEC) TP	Measured on SEC TP	Mult. Factor April	Mult. Factor January
A	9.11	5.5	4.2	8.25	8.81	0.94 (0.04)	0.96
B	9.57	5.5	2.5	8.82	9.85	0.90 (0.03)	1.13
C	10.65	5.5	2.6	9.80	7.13	1.37 (0.06)	1.05
D	14.77	5.5	1.3	13.79	13.73	1.00 (0.03)	1.14

The tables below summarize the results of using the alternative method described above to calibrate losses and SEC's. In general the cases in which losses occurred on the non-field side of the septum show the best agreement between the last column in Table 1 and the SEC(LLS) column in table 2.

Table 2: SEC Calibration Multiplying Factors

Sept. side	Case	Loss Mech.	SEC (LLS)	SEC(Ring)	SEC(Swyd)
no field	C only	AP1	1.116 ±0.023	1.290 ±0.111	1.126 ±0.041
field	C only	CP1	1.060 ±0.047	1.059 ±0.066	0.961 ±0.127
no field	B only	CP2	1.134 ±0.106	±	1.154 ±0.135
field	D only	AP1	1.071 ±0.090	1.055 ±0.073	0.925 ±0.105
no field	D only	CP1	1.124 ±0.087	1.066 ±0.124	1.158 ±0.244
field	A only	AP1	0.702 ±0.030	0.929 ±0.026	0.779 ±0.174
field	A only	CP1	0.862 ±0.047	0.766 ±0.120	0.872 ±0.084

Figures 9 and 10 are included to show the quality of the data used to generate these calibrations. The first figure shows the LLS and sum of the RNSW (ring portion of switchyard) and SWCV (switchyard cave) versus the CSEC/CE010 ratio while changing the skew of CP1. In general the data fits a straight line but not perfectly. The second figure is the same except for the DSEC/CE010 ratio, but also changing the skew of CP1.

Table 3 gives the loss monitor calibrations derived from theses types of curves. Note that error bars are statistical only.

Table 3: Loss Monitor Calibration Multiplying Factors

Sept. side	Case	Loss Mech.	LLS	RNSW	SWCV
no field	C only	AP1	0.554 ±0.001	0.440 ±0.004	0.0317±0.0001
field ↓	C only	CP1	1.298 ±0.007	0.404 ±0.002	0.189 ±0.002
no field	B only	CP2	1.011 ±0.011	±	0.0334±0.0004
field ↑	D only	AP1	0.927 ±0.014	0.349 ±0.015	0.186 ±0.003
no field	D only	CP1	1.104 ±0.015	0.895 ±0.016	0.280 ±0.009
field ↑	A only	AP1	0.976 ±0.014	0.287 ±0.002	0.211 ±0.011
field ↓	A only	CP1	2.327±0.006	0.912 ±0.009	0.238 ±0.001

The loss monitors respond differently depending on which side of the septum the loss occurs on. In general, losses which occur on the field sides of AP1 and CP1 give roughly a factor of two less signal than losses which occur on the non-field sides.

Concluding Remarks:

The SEC's deteriorate over time. The functionality of this deterioration appears to be related to the total integrated beam per unit area that has been put on the SEC. The evidence for this is seen in the Table 1 where the calibrations are different over a three month period, and in figures 1 - 8 where there is seen a position dependence in the response of the SEC.

The loss monitor data appears to show that there is a significant difference in response depending on the way the beam is lost. It appears that beam lost on the field side of the lambertsons gives a smaller count rate from the sum of all the loss monitors than beam lost in the non-field side of the septums. This is possibly due to particles that are being lost being bent away (up or down) from the loss monitors. One simple test of this is to put 'window' frame loss monitors after the septums and observe whether relative responses change in the two conditions.

References:

1. AGS Studies Report No. 319, 12 January 1995

Figure 1: HORIZONTAL SCAN OF DSEC
DSEC and DTEL vs Position on SEC

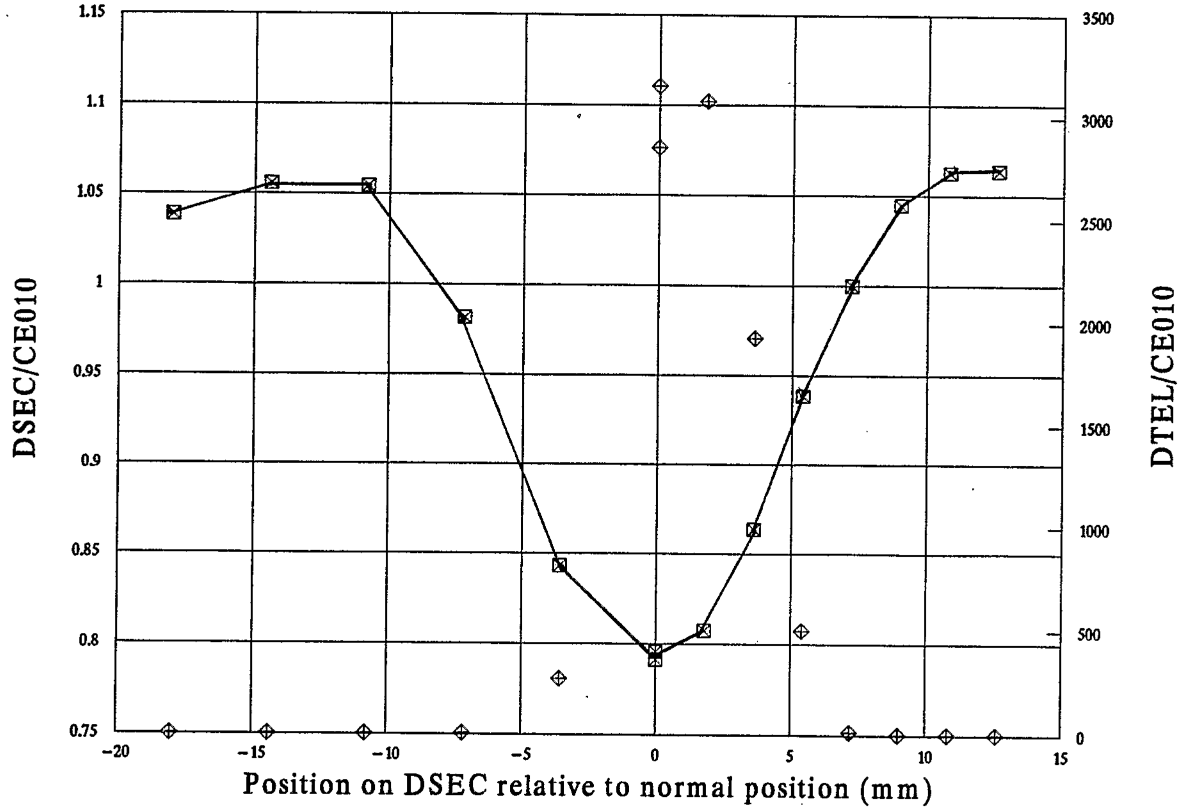

Figure 2: VERTICAL SCAN OF DSEC
DSEC and DTEL vs Postion on DSEC

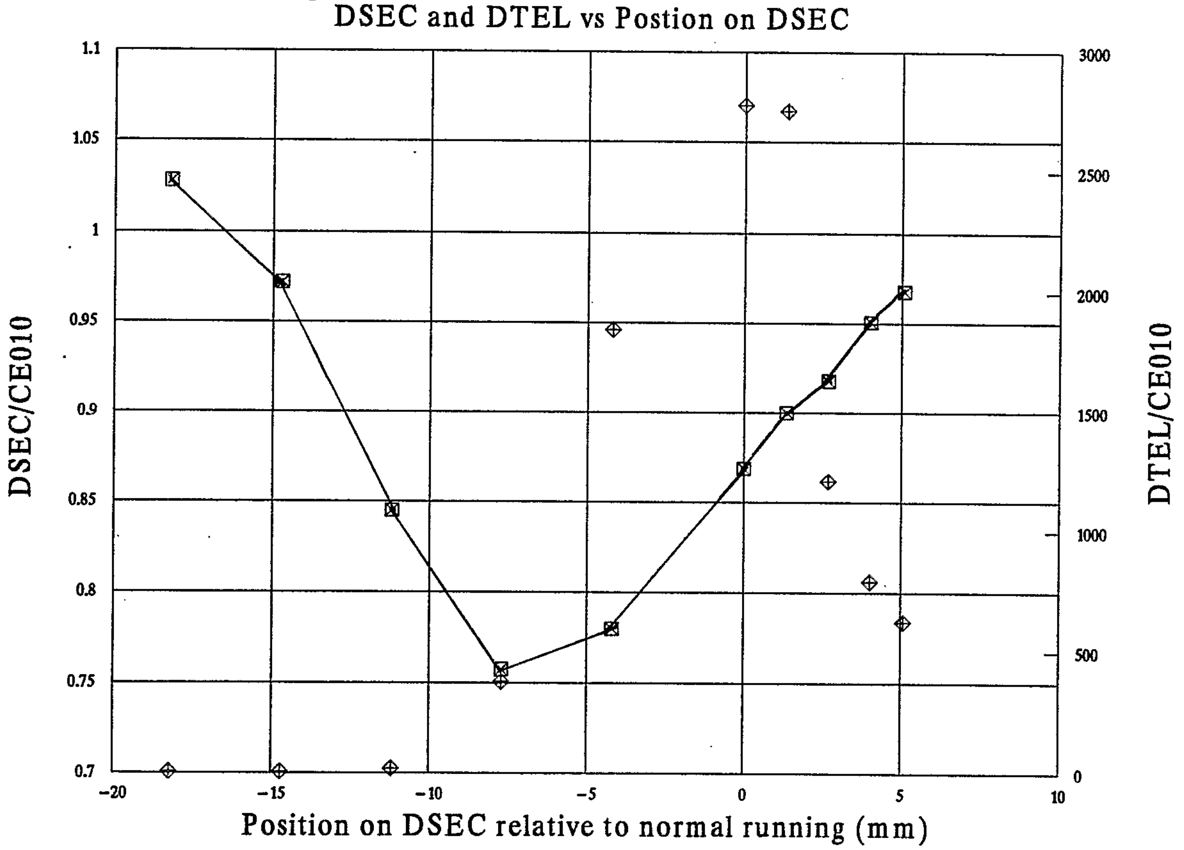

Figure 3: HORIZONTAL SCAN OF ASEC

ASEC and ATEL vs Postion on ASEC

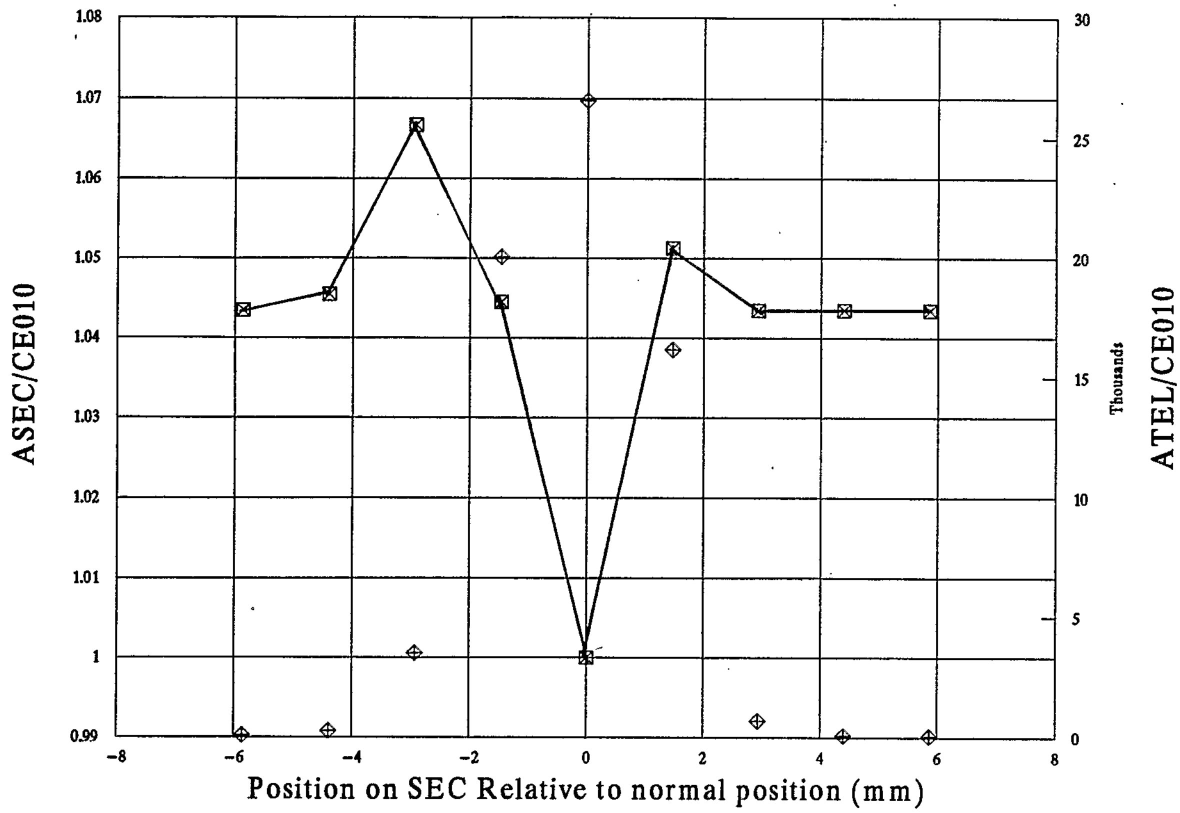

Figure 4: VERTICAL SCAN OF ASEC

ASEC and ATEL vs Postion on ASEC

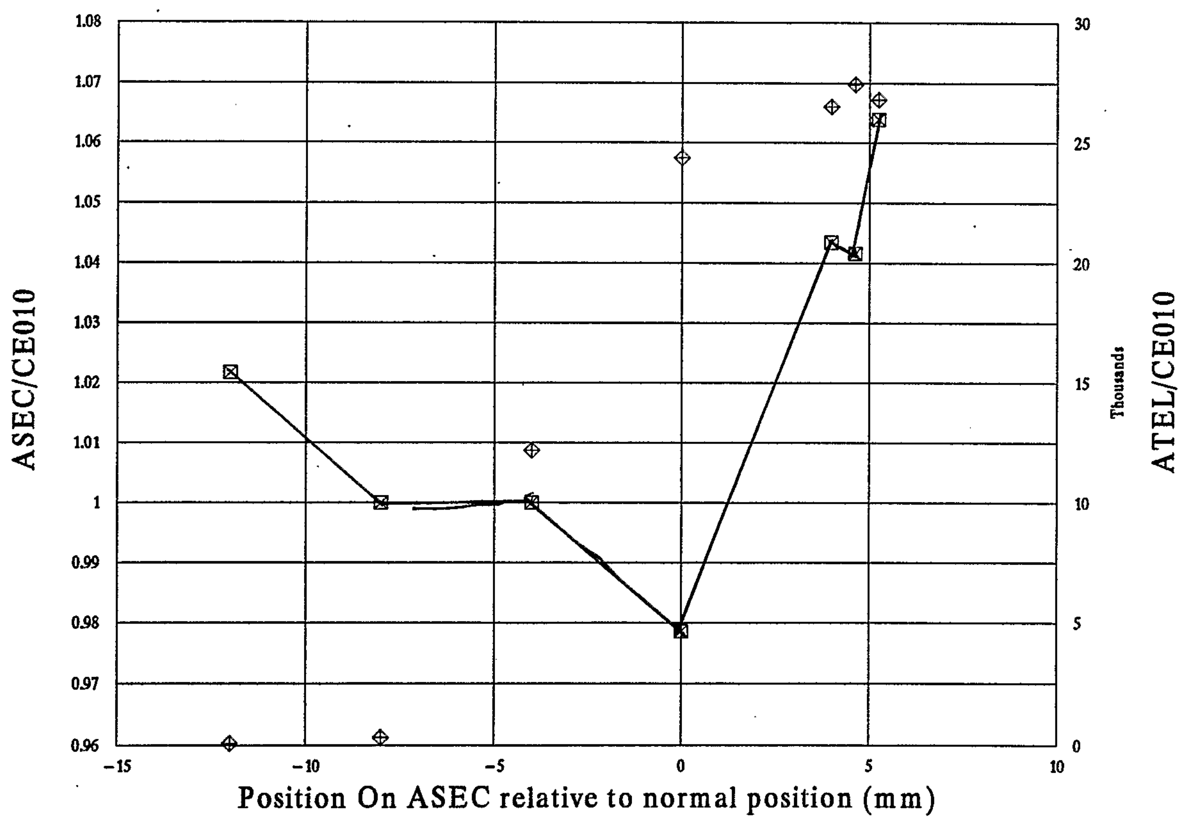

Figure 5: HORIZONTAL SCAN OF B5SEC
B5SEC and B5TEL vs Position on B5SEC

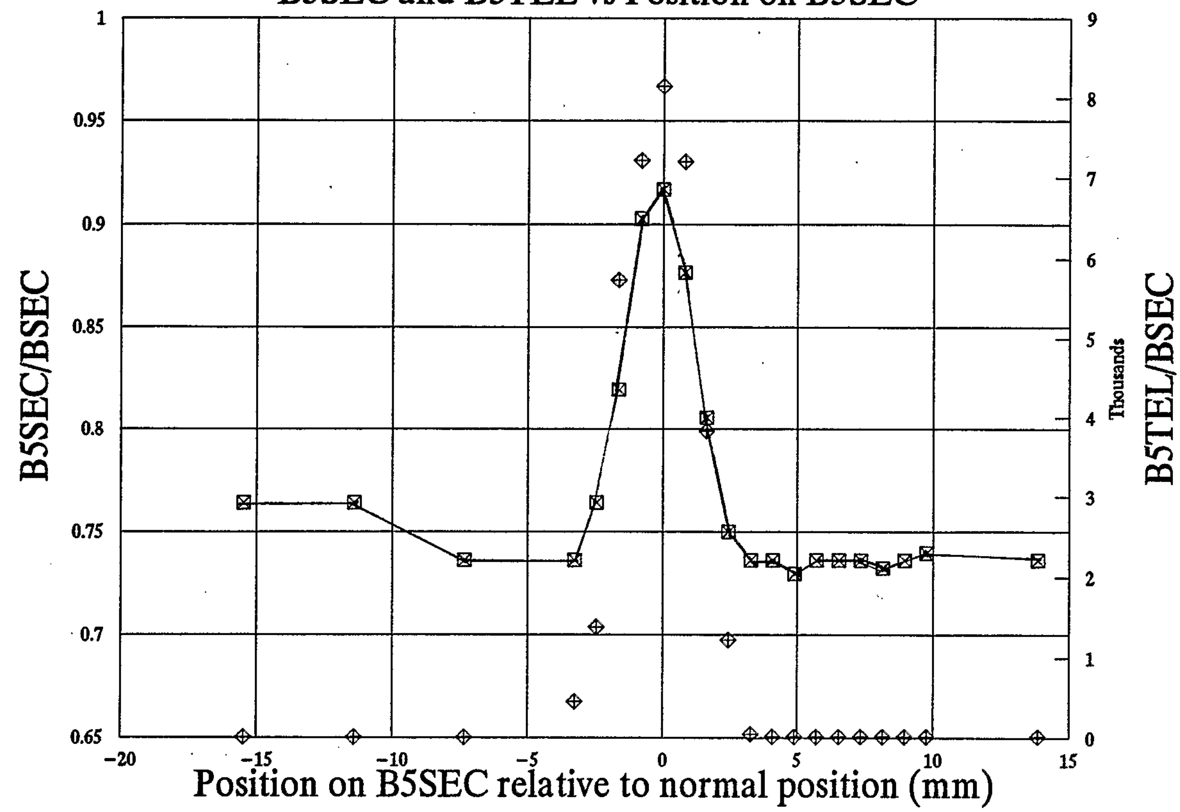

Figure 6: VERTICAL SCAN OF B5SEC
B5SEC and B5TEL vs Position on B5SEC

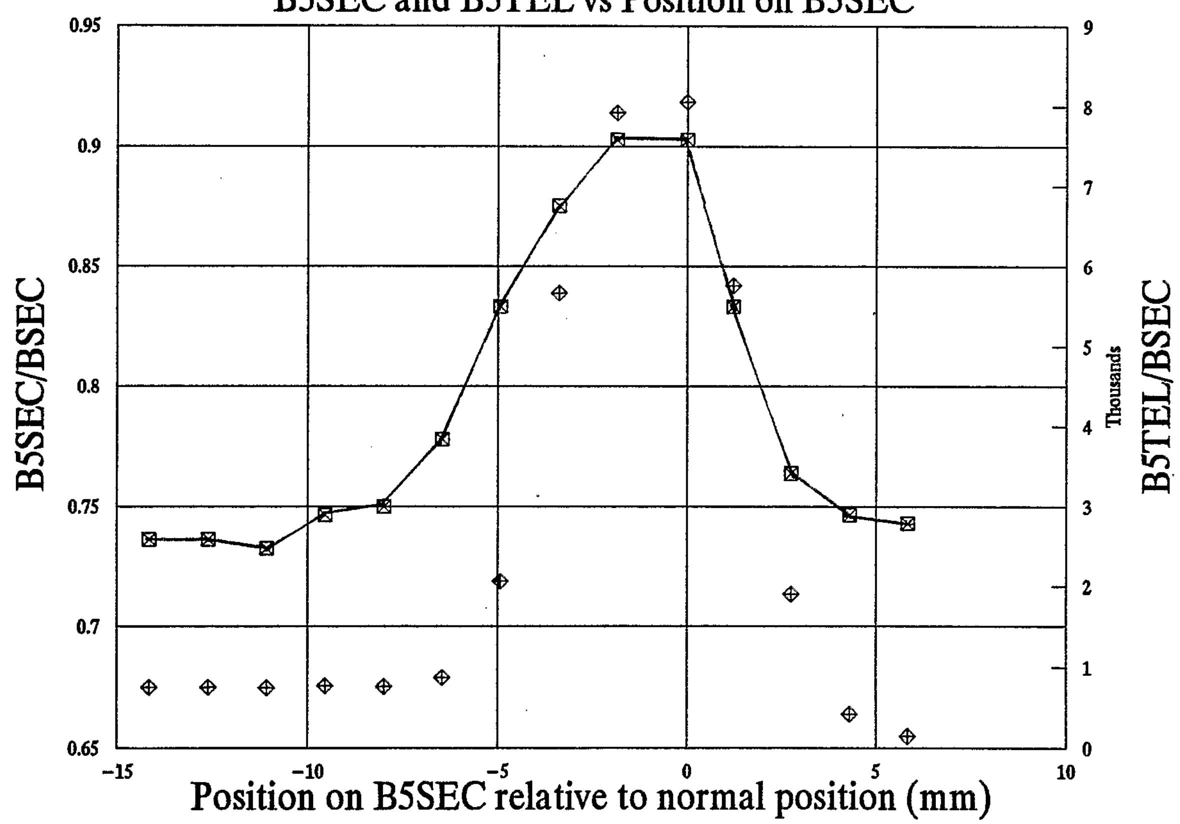

Figure 7: HORIZONTAL SCAN OF CSEC

CSEC and CTEL vs CD357 Commmand

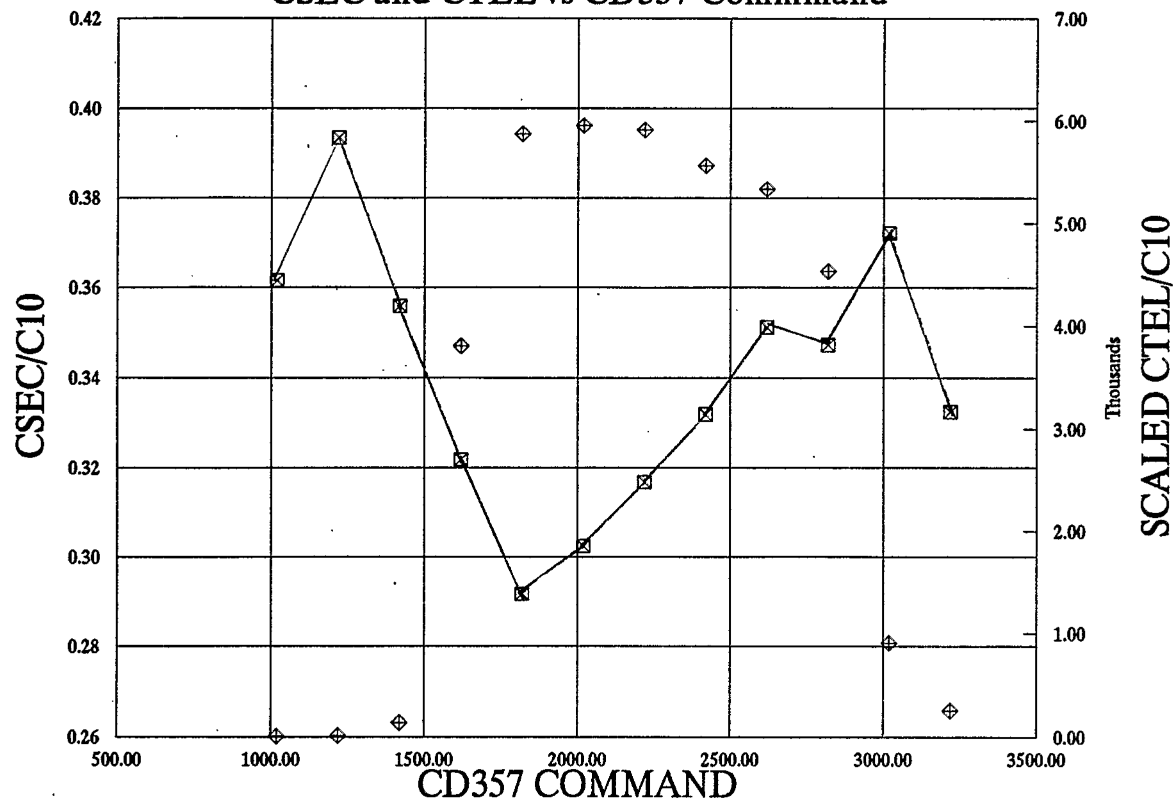

Figure 8: VERTICAL SCAN OF CSEC

CSEC and CTEL vs CP349 Command

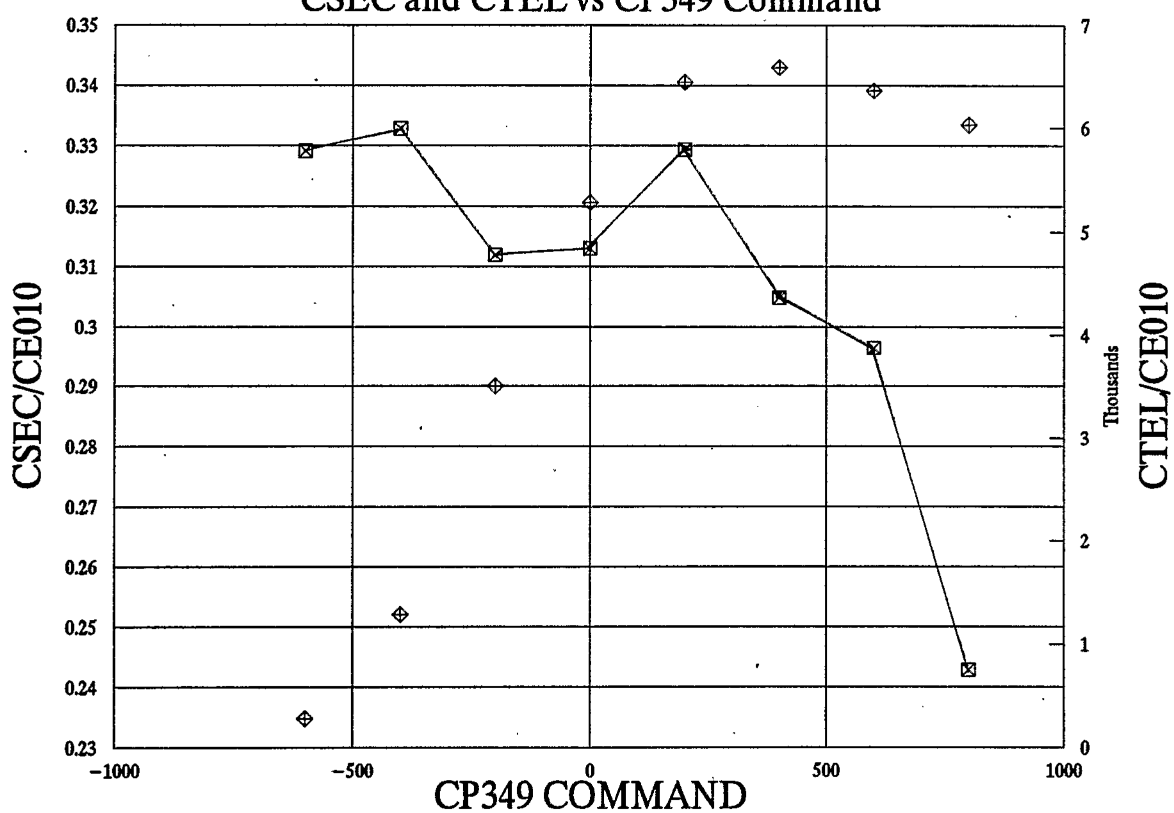

Figure 9: C LINE TRANSPORT EFF. VS RING AND SWYD CAVE LOSSES
LOSS CREATED BY SKEWING CP1

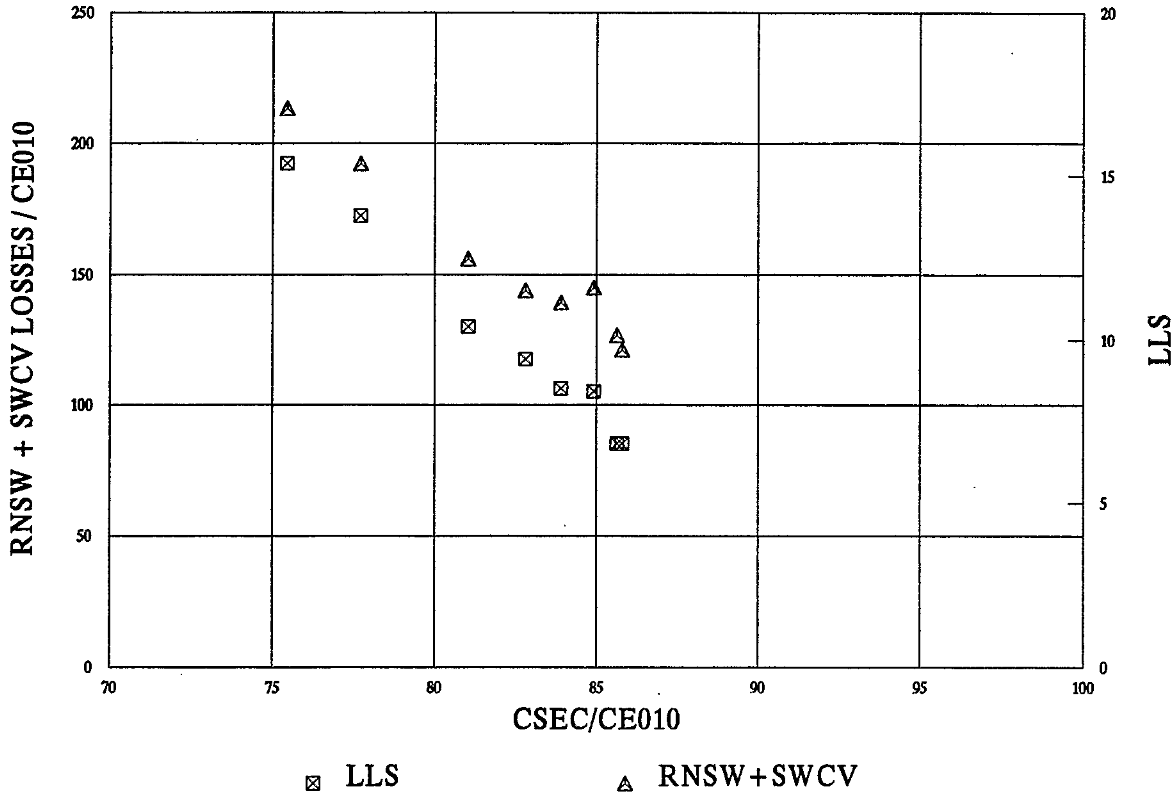

Figure 10: D LINE TRANSPORT EFF. VS RING AND SWYD LOSSES
LOSS CREATED BY SKEWING CP1