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Recycler Ring Aperture Scan: Summary of Results

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Abstract

In this note, we present the summary of results of the aperture scan of the Recycler Ring completed during the Fall of 2000.

1 Introduction

We carried out a detailed aperture scan of the Recycler Ring during the fall of 2000 before the high β insertion [1] was removed. The scan was done in three different parts: (a) Primary scan: we used 3 bumps with all available 27 horizontal and 28 vertical trims; (b) Secondary scan: 9 new correctors (4 vertical + 5 horizontal) were installed; (c) Global scan: where large (almost half - to most of the ring) sections of the ring were examined to see the effect of the high β region.

The major goal of the scan was to locate regions of the ring where the aperture is abnormally narrow or restricted. The restricted regions can be studied in detail afterwards to remedy the situation. The investigation of the effect of the high β region on the Recycler acceptance served as an additional motivation for the replacement of this insertion.

The scan was based on 3-bump technique where the mults (named using the first trim) were closed locally to better than 5-10% of maximum bump amplitude in the relevant plane. The maximum (minimum) trim settings were determined using 50% beam loss criteria or the allowable maximum (minimum) current of ± 5 Amps. At each extremum, the beam loss pattern [2] was recorded using the available Main Injector BLMs (Beam Loss Monitors). At the end of each scan, the beam was centered within the available aperture using the minimum or symmetric loss pattern criteria. During the scan for each mult, the beam orbit, the status of closure, initial trim setting, maximum and minimum settings, beam loss fractions, beam loss patterns and the final trim setting after centering were recorded in the log book.

In section 2, the scan of the horizontal plane is discussed with details of maximum and minimum corrector settings, beam loss pattern and the final corrector settings. Section 3 details the vertical plane. The final summary and results are provided in section 4.

2 Scan of Horizontal Plane

The scan of the horizontal plane was done using 27 primary mults, 5 secondary mults and 6 global scans. The summary of the scan data is listed in Table 1. The data for the primary scan is schematically shown in Figure 1 where the aperture is scaled via the maximum and minimum of the trim current with 50% loss criteria. The trims are shown on the horizontal axis in the order of their location in the ring but with no regard for their actual distances. Figure 2 presents similar data along with the relevant loss fractions and loss patterns. From Figures 1 and 2, the beam aperture is narrow in the regions 400, 628, 210, 230 and 326. More details will be addressed in a future note.

- **Region 400:**
- **Region 628:**
- **Region 210:**
- **Region 230:**
- **Region 326:**

Trim	Nomi. [Amps]	Max. [Amps]	Max. Loss [%]	Max Loss Pat.	Min. [Amps]	Min. Loss [%]	Min. Loss Pat.	Final [Amps]
328	0.80	3.64	10		-3.62	05		0.80
330	2.22	3.40	50	336	-1.40	00		-0.53
340	4.35	5.00	00		-3.40	10	400	1.00
400	-1.06	0.90	50	403	-2.30	50	403	-0.70
402	-2.2	3.20	50	402	-3.90	00		-0.64
404	0.67	5.00	50	403	-2.50	50	425	1.20
406	-1.99	5.00	20	425,509	-5.00	15	408	-2.00
430	1.26	5.00	00	509,511	-3.35	50	510,509	1.50
502	2.42	5.00	00		-2.50	50	504,512	2.42
512	0.92	5.00	25	606	-2.95	50	603	0.92
514	-0.43	3.88	50	528,605	-5.00	50	516,517	-0.56
628	-0.74	1.26	10	630	-2.70	00		-0.74
630	0.12	5.00	00		-5.00	00		0.12
100	0.00	3.36	00		-5.00	00		0.00
102	0.00	3.36	10	104	-3.36	10	104	0.00
104	1.98	4.50	50	sexh	-0.50	50		1.98
106	0.00	5.00	15	sexh	-5.00	10	108	0.00
130	-0.97	4.13	50	206	-5.00	10	210	-0.80
210	-0.06	0.96	00		-1.06	00		0.00
212	0.14	5.00	40	215	-3.25	50	214	0.90
213	-0.62	3.38	50	215	-4.62	50	214	-0.62
216	0.49	3.86	00		-4.10	00		0.49
230	0.00	0.43	50	302	-0.53	50	302,308	-0.05
232	-0.31	2.57	50	302	-3.00	50	305	-0.31
310	-0.29	5.00	00		-2.35	00		0.80
312	-1.72	1.18	50		-4.70	50	314	-1.72
326	1.34	2.56	50		0.66	50		1.36
222	0.00	4.03	50	209,228	-4.13	50	205,228	0.00
310	0.81	5.00	00	427,519	-3.80	00	427,511	0.65
312	-1.72	5.00	15	314	-5.00	15	314	0.00
320	0.00	3.50	00	521	-3.50	00	521	0.00
324	0.00	2.50	50	328	-3.80	50	521	-0.65
402-514	-0.64	1.60	50	408	-5.00	05	427,508	
402-630	-0.64	1.47	50	408,424	-5.00	45	526	
402-212	-0.64	0.75	50	408,424	-3.75	50	516,205	
100-310	0.00	0.80	50	408,212	-2.47	50	427,108	
402-312	-0.64	2.10	50	205,212	-2.35	50	108	
404-512	0.87	4.20	50	410,205	-0.80	50	424	

Table 1: Summary of horizontal plane scan for the Recycler Ring: The first 27, the next 5 and the last 6 rows represent the primary, secondary and the global scan data respectively.

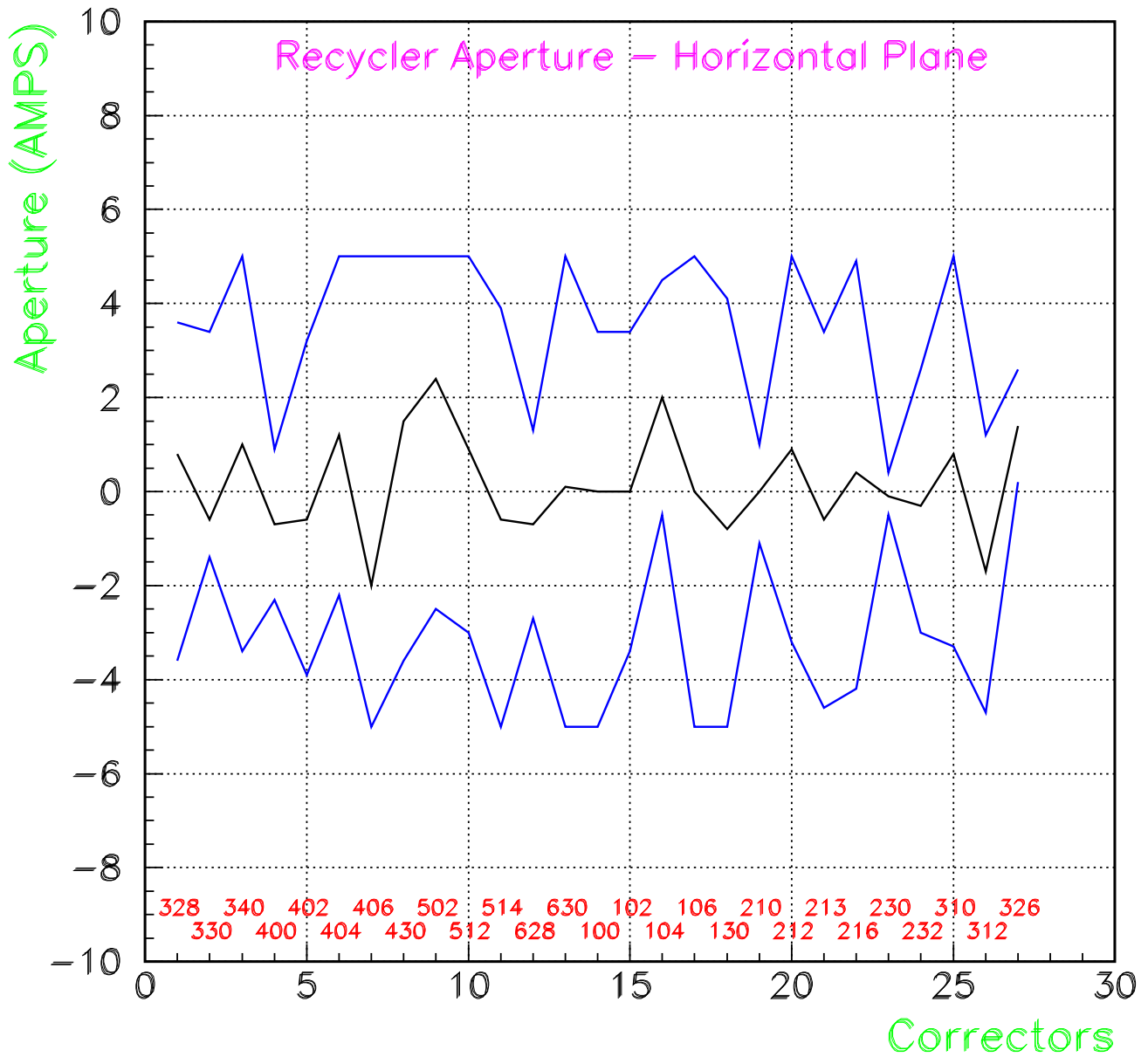


Figure 1: In the above plot for horizontal plane, the blue lines show the aperture (in amps) on both sides while the black line shows the final setting of the mults after centering. The trims are shown in red on the bottom margin.

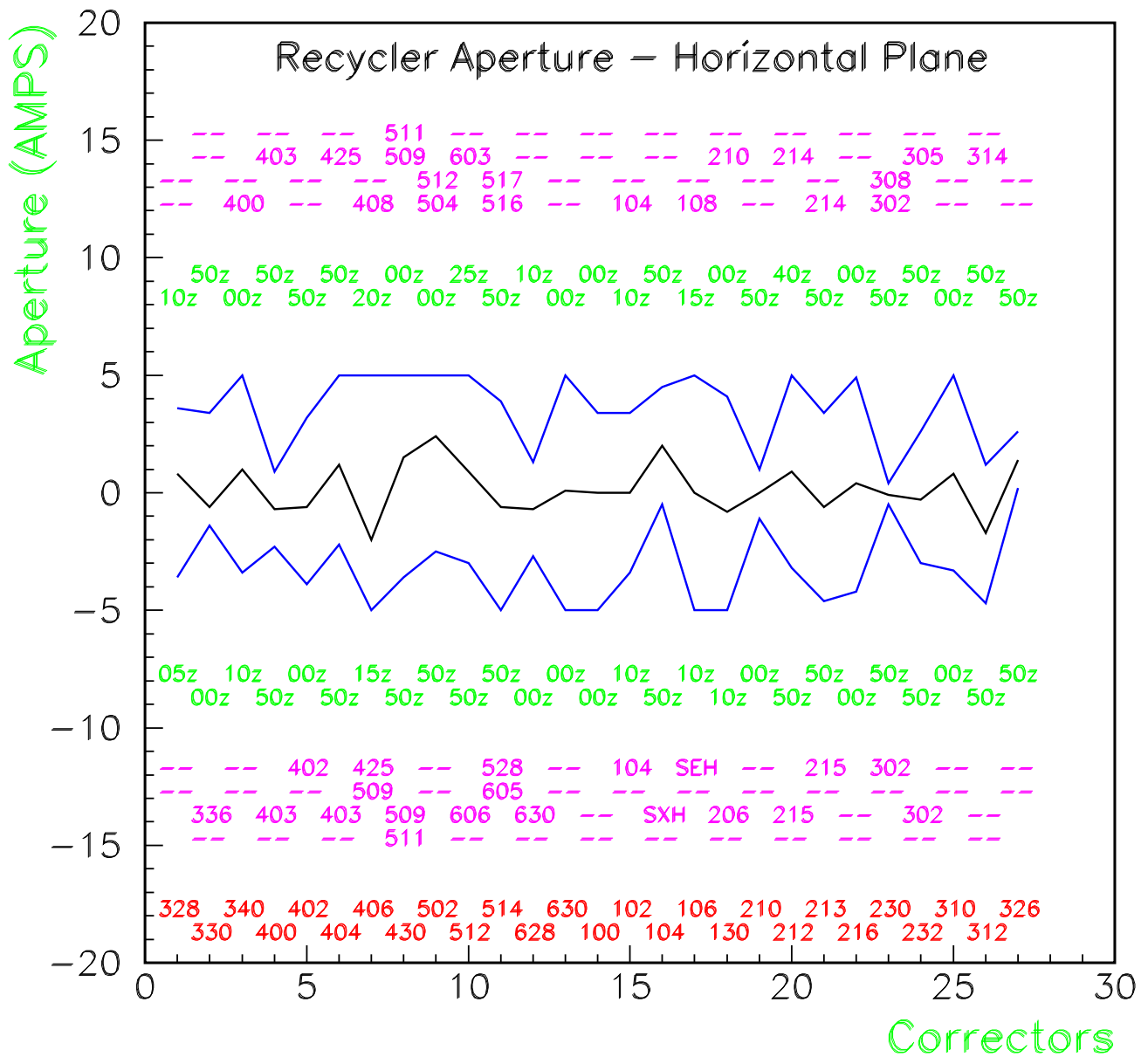


Figure 2: Here, the beam loss fractions (green) and the beam loss patterns (magenta) are also shown for each mult.

3 Scan of Vertical Plane

The scan of the vertical plane was done using 27 primary mults, 4 secondary mults and 5 global scans. The summary of the scan data is listed in Table 2. The data for the primary scan is schematically shown in Figure 3 where the aperture is scaled via the maximum and minimum of the trim current with 50% loss criteria. The trims are shown on the horizontal axis in the order of their location in the ring but with no regard for their actual distances. Figure 4 presents similar data along with the relevant loss fractions and loss patterns. From Figures 3 and 4, the beam aperture is narrow in the regions 325-327, 403-405, 513-515, and 211-215. More details will be addressed in a future note.

- **Region 325-327:**
- **Region 403-405:**
- **Region 513-515:**
- **Region 211-215:**

Trim	Nomi. [Amps]	Max. [Amps]	Max. Loss [%]	Max Loss Pat.	Min. [Amps]	Min. Loss [%]	Min. Loss Pat.	Final [Amps]
327	2.07	4.06	50	329	-0.10	50		2.07
329	0.00	3.70	50	331,336	-4.10	50	331,335	-0.20
331	-0.09	5.00	50	341	-3.59	50	333	0.09
341	0.25	3.79	00	403	-3.76	50	403	1.75
401	0.18	3.68	50	403	-3.02	50	403	0.18
403	1.12	4.62	50	409,413	-0.58	50	427	2.00
405	-0.58	1.50	45	425,426	-5.00	45	407,429	-1.75
429	1.63	3.25	50	511	-2.50	50	501	0.38
501	1.93	5.00	05	503,511	-0.50	50	509	3.00
513	1.00	3.50	50	515,613	-1.50	50	521,529	1.00
515	-0.63	1.00	50	517,625	-3.00	50	521,529	-1.10
629	0.17	2.00	50	517,625	-4.00	50	517,527	-1.00
631	-2.65	1.00	50		-5.00	30		-2.30
641	-1.86	2.40	50	103,102	-5.00	00	012,103	-2.25
101	0.55	5.00	40	103	-3.50	50	103	0.57
103	0.29	4.50	50	105	-4.00	50		0.29
107	-0.78	1.50	50	115	-4.75	50	109,129	-1.50
209	-0.73	4.40	25	211	-3.00	50	211	1.10
211	-1.86	0.23	05	205,213	-5.00	05		-2.40
213	2.40	4.90	50	215	-0.30	05	215	1.90
215	2.55	4.74	05	219	-5.00	25	229	2.35
217	-2.48	3.48	50	223	-2.10	15	223	-1.40
231	0.91	3.70	00		-2.10	00		0.90
301	-0.83	4.50	05		-5.00	00		-0.83
309	0.00	2.50	30	315	-4.60	50	315	-0.80
311	0.55	5.00	30	313	-4.40	05		-0.70
325	-1.65	1.00	50	328	-4.50	50	328	-1.65
611	0.00	3.40	50	630	-2.00	50	613	0.70
609	0.00	4.80	50	611	-4.00	50	613	0.40
513	0.99	4.40	50	523	-1.85	50	515,609	0.25
515	-1.65	2.46	50	603	-3.09	50	516,521	-0.30
401-515	0.18	3.00	50	403,415	-1.80	50	403,425	
401-611	0.18	2.68	50	407,417	-2.70	50	403,501	
401-101	0.18	2.20	50	415,429	-1.40	50	521,511	
401-209	0.18	1.75	50	511,630	-1.60	50	427,613	
401-325	0.18	1.60	50	209,205	-1.80	50	403,425	

Table 2: Summary of vertical plane scan for the Recycler Ring: The first 27, the next 4 and the last 5 rows represent the primary, secondary and the global scan data respectively.

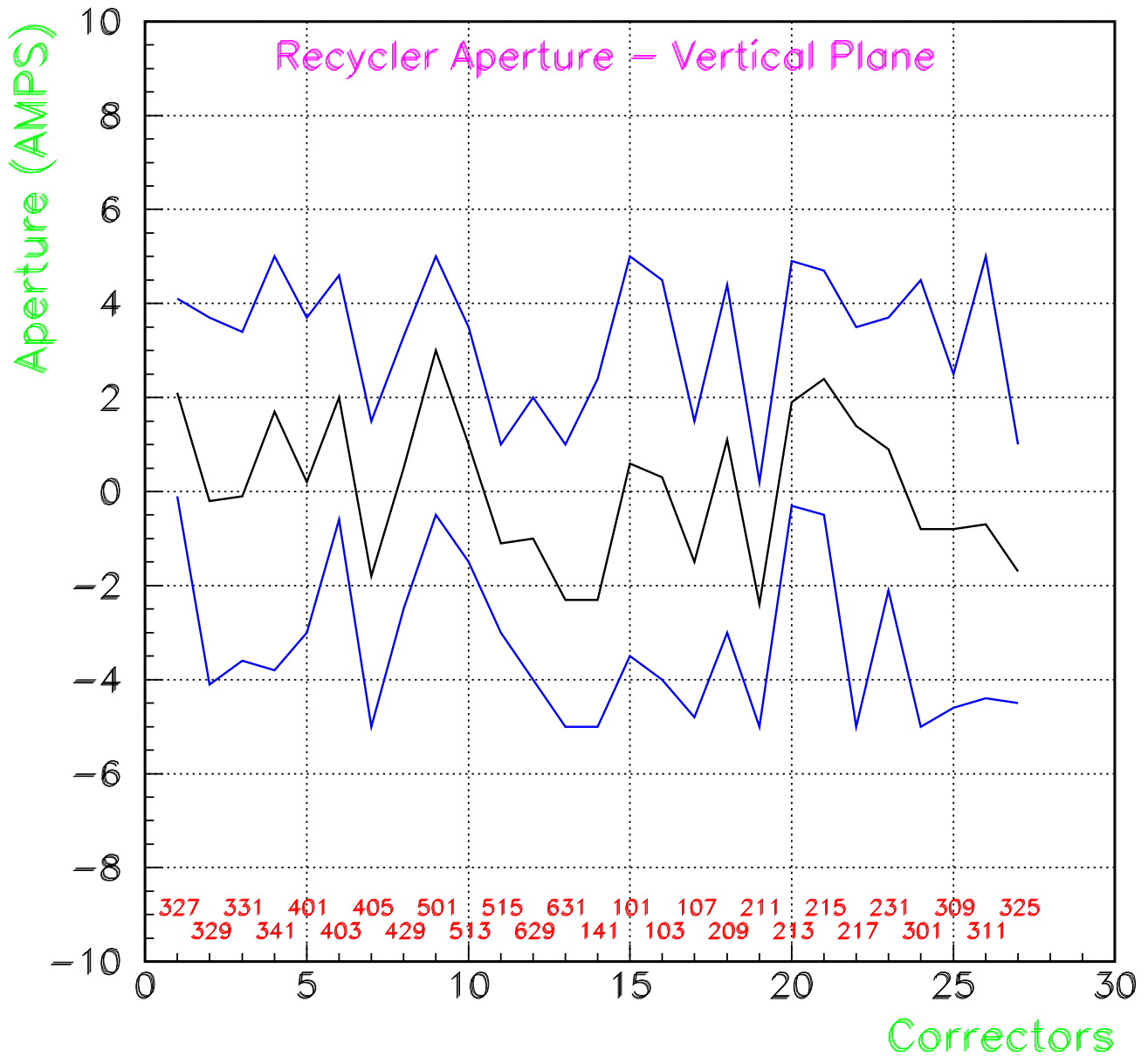


Figure 3: In the above plot for vertical plane, the blue lines show the aperture (in amps) on both sides while the black line shows the final setting of the mults after centering. The trims are shown in red on the bottom margin.

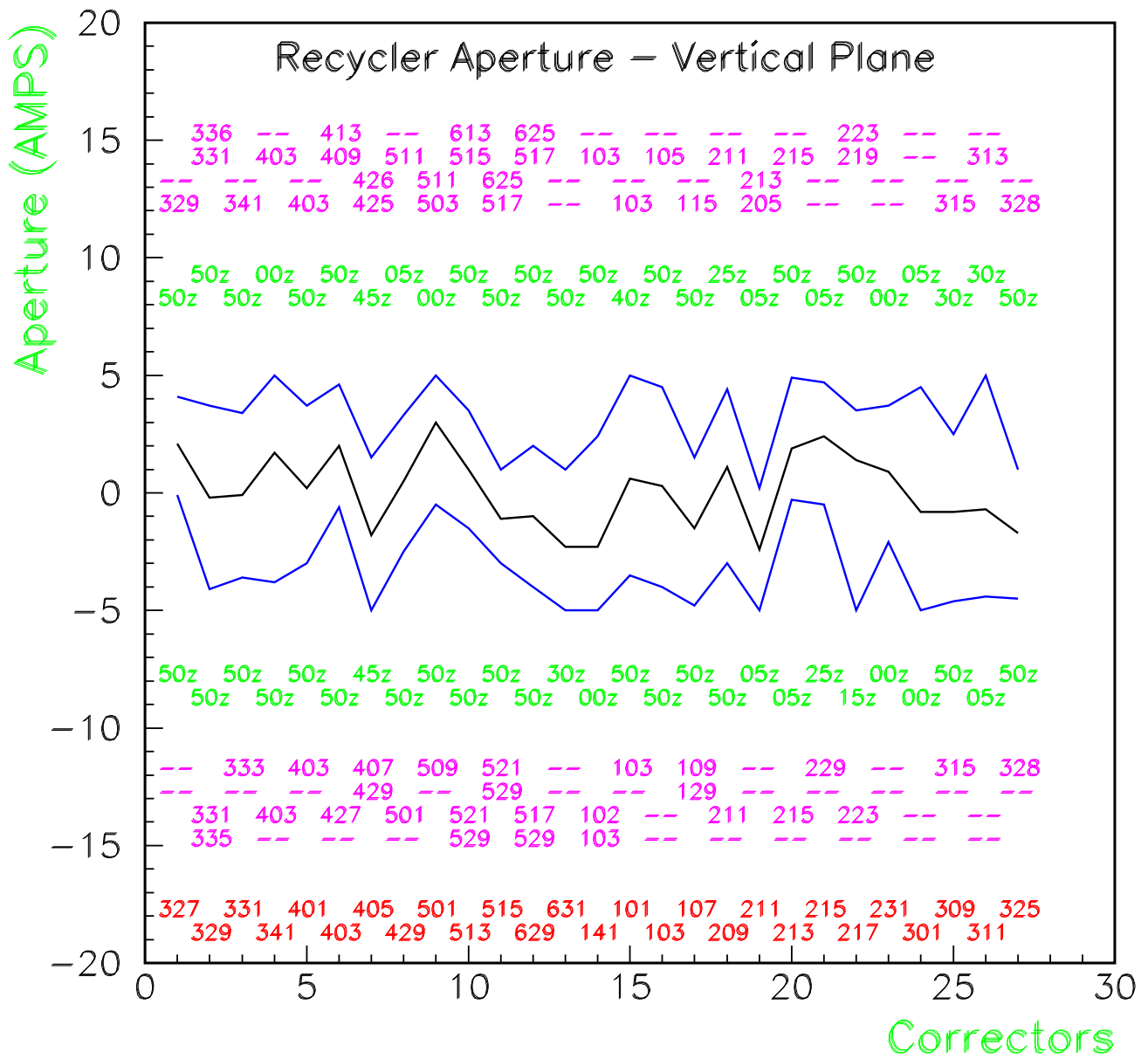


Figure 4: Here, the beam loss fractions (green) and the beam loss patterns (magenta) are also shown for each mult.

4 Summary and Outlook

We completed a rough scan of the Recycler Ring aperture in the horizontal and vertical planes. This scan helped to identify the problems associated with the high β section which is already being replaced. Also additional trims are being added in both planes for better beam control. Additional results will be summarized in a future note.

References

- [1] Gerry Jackson, “The Fermilab Recycler Ring Technical Design Report”, November 1996, Fermilab-TM-1991.
- [2] The program R99 was used for monitoring the beam loss locations and also R48 when necessary for centering.

5 Appendix: Aperture Limitations (known)

Here is a list of known aperture limitations around the Recycler Ring.

- Lambertsons: The field free region of the Lambertsons has a diameter of 3 inches (37-8 mm).
Locations: 212, 328, 402
- Kickers: The diameter of the kicker apertures is 3 inches (37-8 mm).
Locations: 400, 150
- Stochastic Cooling tanks:
Locations: 102-103, 103-104, 211-212, 212-213