Geometrical Layout and Mechanical details of CMS End Cap RPCs

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Abstract

The purpose of this document is to explain the engineering layout and the mechanical details of the CMS end cap RPCs. The standard CMS R, ϕ, Z coordinate system has been followed for specifying RPC dimensions and details.

The forward RPC trigger geometry is described in the ref. [1]. On the basis of this information a detailed scheme for the chamber geometry has been derived.

The muon end cap RPC layout in CMS experiment consists of four stations designated as RE1, RE2, RE3 and RE4. The four stations are symmetrical with respect to the Z=0 plane in + and – direction. The layout is shown in figure 1.

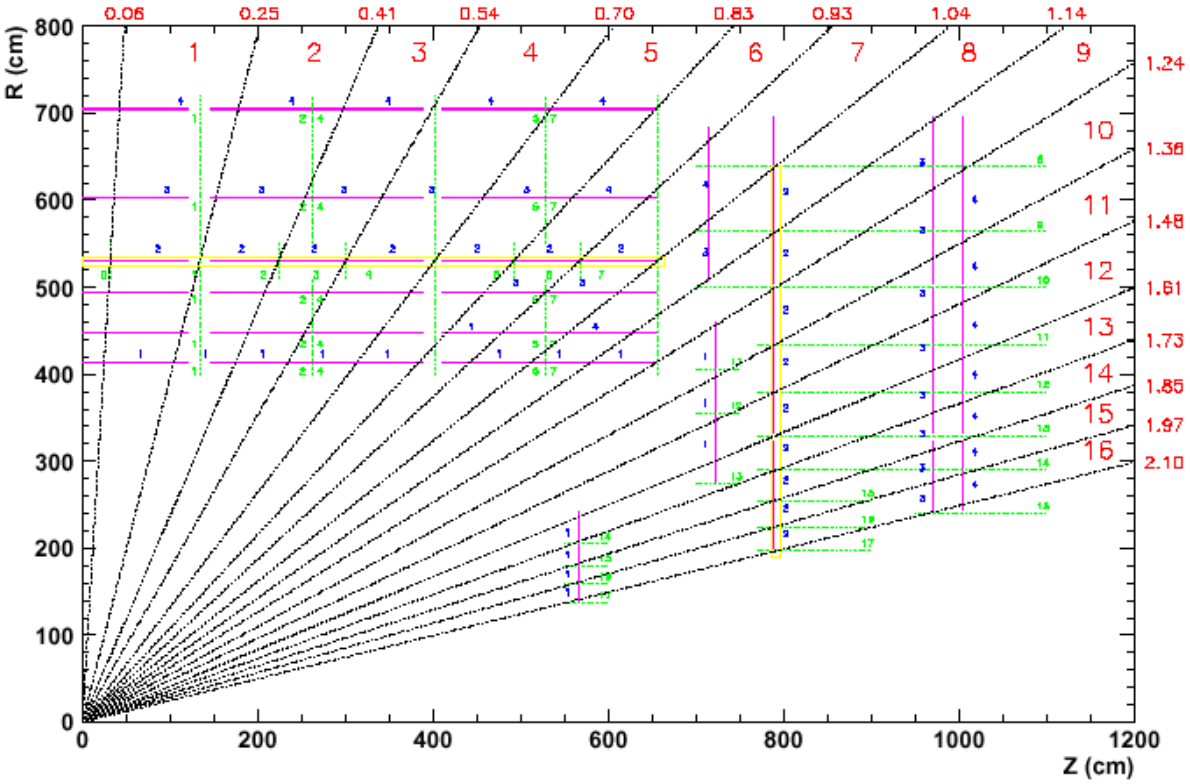


Fig. 1

Station 1 is subdivided into 36 ϕ sectors (10º each). Each sector is composed of RE/1/1, RE/1/2 and RE/1/3 chambers as shown in Fig 2. The chamber RE/1/1 is positioned at different Z (as shown in Fig. 1).

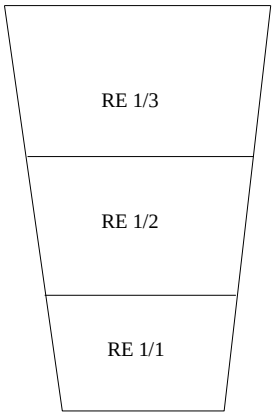


Fig. 2 : 10 ° sector of station 1

Stations 2,3 and 4 will be subdivided into 18 sectors (20 degrees each) as shown in Fig. 3. Each sector is composed of one RE */1, two each of RE */2 and RE */3 chambers. **(*** denotes the station number)

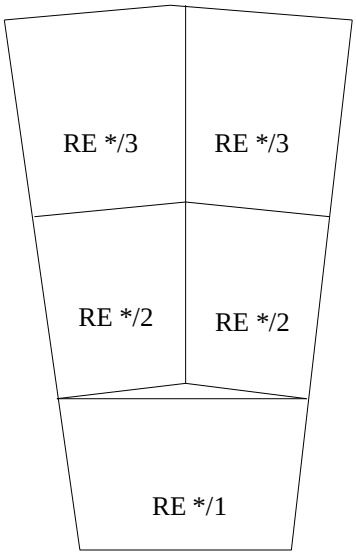


Fig. 3: 20 ° sector of RE 2,3,4

All chambers consist of three gaps, except RE/3/1 and RE/4/1 which consist of two gaps. The gaps are referred in the following order: gap (i), (ii) and (iii), as shown in figure 4 a and b.

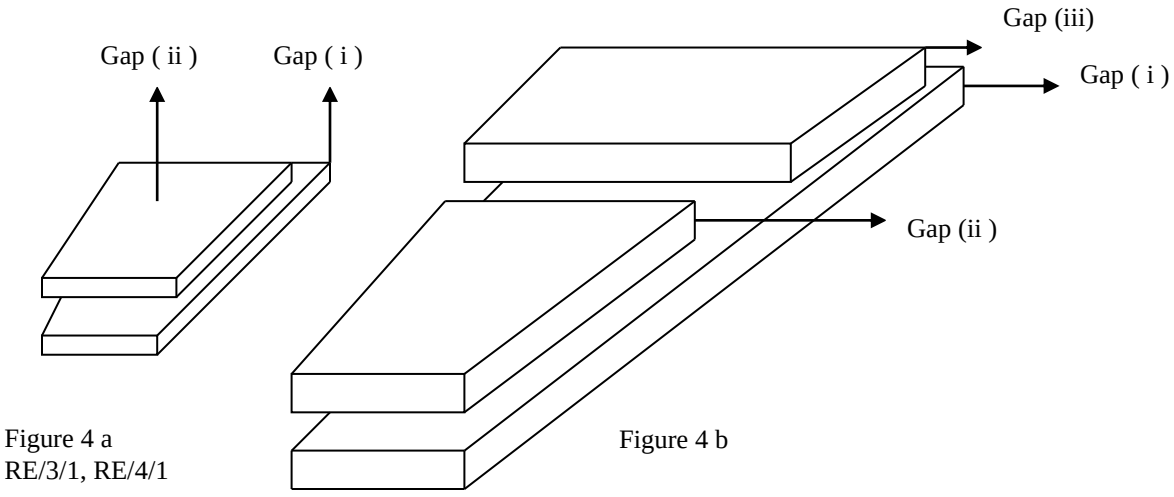


Figure 4 a
RE/3/1, RE/4/1

Figure 4 b

Figure 4: Gap segmentation

The strip read out plane is located between the gaps and is divided into η segments denoted as a, b, c and d in this document. Segment ‘a’ is always located at the highest η region of the chamber. Each η segment

will have thirty-two 5/16º strips for every ten degree sector. Twenty degrees eta segments accordingly have 64 strips. Fig. 5 shows the η segments. Eta regions per chamber are given in table I.

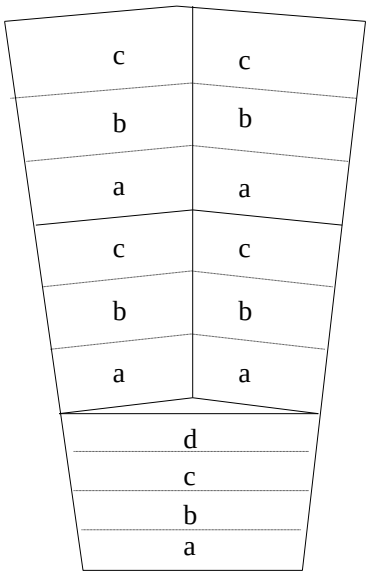
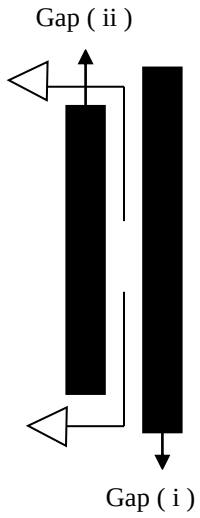


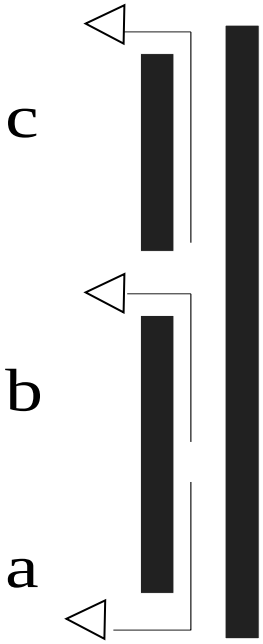
Fig. 5: η segments

Table I:

Chamber type	# of η regions
RE1/1	4
RE1/2	3
RE1/3	3
RE2/1	4
RE2/2	3
RE2/3	3
RE3/1	2
RE3/2	3
RE3/3	3
RE4/1	2
RE4/2	3
RE4/3	3

The position of the front-end board for each η region is fixed so as to minimize the total time jitter of the signal. Figure 6 a, b and c show signal extraction from chambers covering two, three and four eta segments respectively.





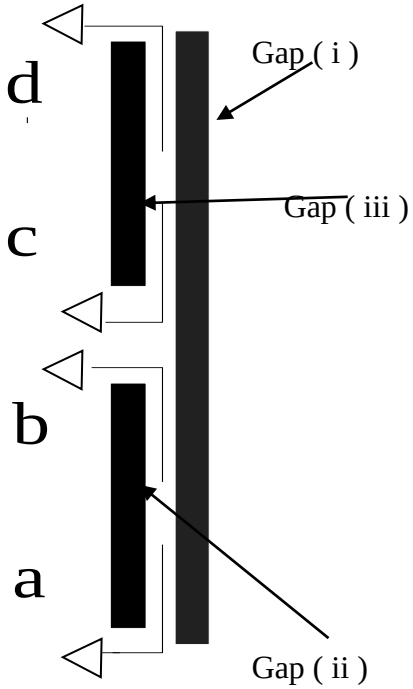


Fig. 6a Fig. 6b Fig. 6c

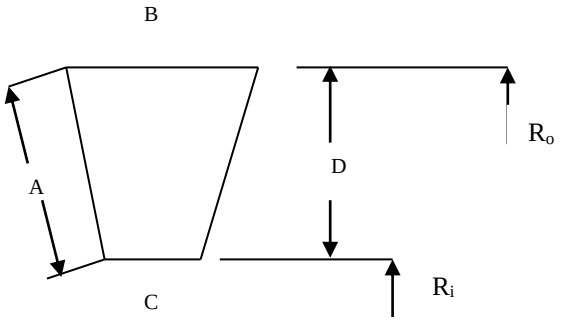
Fig. 6 : Signal extraction layout

In the following tables relevant information about the dimensions of chambers, gaps, active areas and pick up strips are given. As the chambers, gaps and strips are trapezoidal, dimensions of the aligned length (A), top side (B), bottom (C) and the vertical height (D) are given for complete description. Ri, Ro and Z specify the positions on end cap yokes.

In Table III, a general data for each chamber is summarized. The active area given in table V indicates the graphite-coated area of the continuous gap (i), cut gaps (ii) & (iii), refer to Fig. 4 & 6. Active area sides are offset inwards by 25 mm's. Table III summarizes the geometrical data of the chambers. Table IV summarize the data of the gaps (i), (ii) and (iii).

Table II: Chamber Data

	RE 1/1	RE 1/2	RE 1/3	RE 2/1	RE 2/2	RE 2/3	RE 3/1	RE 3/2	RE 3/3	RE 4/1	RE 4/2	RE 4/3
No. of chambers (Plus & Minus Z)	36*2	36*2	36*2	18*2	36*2	36*2	18*2	36*2	36*2	18*2	36*2	36*2
η Segments	4	3	3	4	3	3	2	3	3	2	3	3
ϕ Coverage, deg.	10	10	10	20	10	10	20	10	10	20	10	10
Strips/η Segment	32	32	32	64	32	32	64	32	32	64	32	32
No. of channels/chamber	128	96	96	256	96	96	128	96	96	128	96	96



R_0 = Radius from beam line (Low eta)

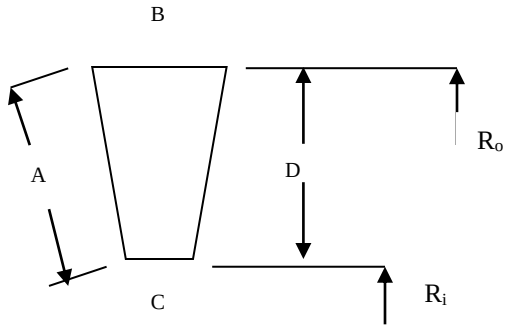
R_i = Radius from beam line (High eta)

Table: III

Chambers Geometrical Data

Station	Ri	Ro	A	B	C	D	Thickness	Z Position rpc *Z of cu-strips*
RE1/1	1363	2396	1037	526 (510)	345 (329)	1033	36	5651 *~5670 &5688*
RE1/2	2750	4644	1901	999	676	1894	30	6953 & 7235 *6968 & 7250*
RE1/3	5065	6820	1762	1380	1073	1755	30	7098-7155 *7083 & 7140*
RE2/1	1960	3241	1301	1251	799	1281	36	7865-7902 *7883 –7920**
RE2/2	3299	4986	1693	979	684	1687	36	7865-7902
RE2/3	5001	6955	1961	1323	981	1954	36	7865-7902
RE3/1	2435	3241	819	1251	966	806	36	9775-9738 *9757-9720**
RE3/2	3299	4986	1693	979	684	1687	36	9775-9738
RE3/3	5001	6955	1961	1323	981	1954	36	9775-9738
RE4/1	2655	3241	595	1251	1044	586	36	10676-10639 *10654-10621**
RE4/2	3299	4986	1693	979	684	1687	36	10676-10639
RE4/3	5001	6955	1961	1323	981	1954	36	10676-10639

*same for x/2 & x/3; x is 2, 3 or 4 depending on station number.



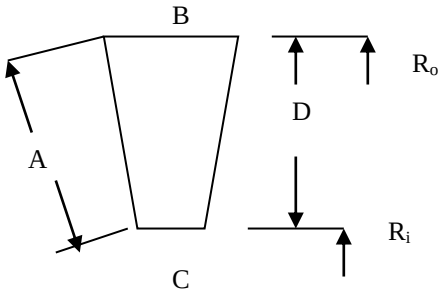
R_i = Radius from beam line (High eta)

R_0 = Radius from beam line (Low eta)

Table: IV

Gaps Details

Station		Ri	Ro	A	B	C	D	Thickness
RE1/1	RE1/1(i)	1375	2384	1013	467	291	1009	6.0
	RE1/1(ii)	1390	1797	408	365	293	407	6.0
	RE1/1(iii)	1817	2369	554	465	368	552	6.0
RE1/2	RE1/2(i)	2768	4626	1865	860	535	1858	6.0
	RE1/2(ii)	2780	4056	1281	760	537	1276	6.0
	RE1/2(iii)	4066	4614	550	858	762	548	6.0
RE1/3	RE1/3(i)	5083	6802	1726	1240	940	1719	6.0
	RE1/3(ii)	5098	6387	1294	1168	943	1289	6.0
	RE1/3(iii)	6397	6787	391	1238	1170	390	6.0
RE2/1	RE2/1(i)	1972	3229	1277	1190	746	1257	6.0
	RE2/1(ii)	1987	2525	546	941	751	538	6.0
	RE2/1(iii)	2545	3214	680	1184	948	670	6.0
RE2/2	RE2/2(i)	3311	4974	1669	921	630	1663	6.0
	RE2/2(ii)	3316	4336	1014	809	632	1010	6.0
	RE2/2(iii)	4346	4959	615	918	811	613	6.0
RE2/3	RE2/3(i)	5013	6943	1937	1265	927	1930	6.0
	RE2/3(ii)	5028	6392	1370	1169	930	1364	6.0
	RE2/3(iii)	6402	6928	528	1262	1170	526	6.0
RE3/1	RE3/1(i)	2447	3229	795	1190	914	782	6.0
	RE3/1(ii)	2462	3214	764	1184	919	752	6.0
RE3/2	RE3/2(i)	3311	4974	1669	921	630	1663	6.0
	RE3/2(ii)	3326	4336	1014	809	632	1010	6.0
	RE3/2(iii)	4346	4959	615	918	811	613	6.0
RE3/3	RE3/3(i)	5013	6943	1937	1265	927	1930	6.0
	RE3/3(ii)	5028	6392	1370	1169	930	1364	6.0
	RE3/3(iii)	6402	6928	528	1262	1170	526	6.0
RE4/1	RE4/1(i)	2667	3229	571	1190	991	562	6.0
	RE4/1(ii)	2682	3214	532	1184	997	532	6.0
RE4/2	RE4/2(i)	3339	4974	1669	921	630	1663	6.0
	RE4/2(ii)	3326	4336	1014	809	632	1010	6.0
	RE4/2(iii)	4346	4959	615	918	811	613	6.0
RE4/3	RE4/3(i)	5013	6943	1937	1265	927	1930	6.0
	RE4/3(ii)	5028	6392	1370	1169	930	1364	6.0
	RE4/3(iii)	6402	6928	528	1262	1170	526	6.0



R_0 = Radius from beam line (Low eta)

R_i = Radius from beam line (High eta)

BLUE = MAX. EFFEC. AREA OF CERTAIN RPC

Table: V

Active Area

Station	Gap	Ri	Ro	A	B	C	D	Active Area M^2
	RE1/1(i)	1400	2359	963	413	245	959	0.315
RE1/1	RE1/1(ii)	1415	1772	358	310	248	357	0.099
	RE1/1(iii)	1842	2344	504	410	322	502	0.184
RE1/2	RE1/2(i)	2795	4599	1811	805	489	1804	1.170
	RE1/2(ii)	2807	4031	1229	705	491	1224	0.733
	RE1/2(iii)	4091	4587	498	803	716	496	0.378
RE1/3	RE1/3(i)	5110	6775	1671	1186	894	1665	1.736
	RE1/3(ii)	5125	6362	1242	1113	897	1237	1.245
	RE1/3(iii)	6422	6760	339	1183	1124	338	0.392
RE2/1	RE2/1(i)	1997	3204	1226	1130	704	1207	1.107
	RE2/1(ii)	2012	2500	495	881	710	488	0.388
	RE2/1(iii)	2570	3189	629	1125	906	620	0.629
RE2/2	RE2/2(i)	3336	4949	1619	866	584	1613	1.169
	RE2/2(ii)	3351	4311	964	754	586	960	0.644
	RE2/2(iii)	4371	4934	565	863	765	563	0.458
RE2/3	RE2/3(i)	5038	6918	1887	1211	882	1880	1.966
	RE2/3(ii)	5053	6367	1319	1114	884	1314	1.313
	RE2/3(iii)	6453	6903	478	1208	1125	476	0.555
RE3/1	RE3/1(i)	2472	3204	744	1130	872	732	0.733
	RE3/1(ii)	2487	3189	713	1125	877	702	0.703
RE3/2	RE3/2(i)	3336	4949	1619	868	584	1613	1.169
	RE3/2(ii)	3351	4311	964	754	586	960	0.644
	RE3/2(iii)	4371	4934	565	863	765	563	0.458
RE3/3	RE3/3(i)	5038	6918	1887	1211	882	1880	1.966
	RE3/3(ii)	5053	6367	1319	1114	884	1314	1.313
	RE3/3(iii)	6427	6903	478	1208	1125	476	0.555
RE4/1	RE4/1(i)	2692	3204	520	1130	949	512	0.533
	RE4/1(ii)	2707	3189	490	1125	955	482	0.502
RE4/2	RE4/2(i)	3336	4949	1619	866	584	1613	1.169
	RE4/2(ii)	3351	4311	964	754	586	960	0.644
	RE4/2(iii)	4371	4934	565	863	765	563	0.458
RE4/3	RE4/3(i)	5038	6918	1887	1211	882	1880	1.966
	RE4/3(ii)	5053	6367	1319	1114	884	1314	1.313
	RE4/3(iii)	6427	6903	478	1208	1125	476	0.555

The information about chamber strips is given in table IV a, b, c and d for the η regions a, b, c and d, respectively. Regionally η regions should be defined by circles of the ϕ projection centered at R=0, at each Z position. However for optimization and simplification a given chamber will be subdivided in to η regions by drawing horizontal line between the two intersecting points that the eta circle makes with active area trapezoidal envelope of a certain gap. The reference cutting line for strips, gaps, active area & chamber passes through the mid point of the perpendicular distance between horizontal line & respective eta circle as shown in Fig. 7. Ri and Ro values for a given η region will be that for the central strip. The values given in the tables for the major and minor width(base) and the height refers to the central strip only and should be considered as minimum numbers. Strips at the edge of the chamber will have slightly larger widths (by a few mm maximum) and slightly larger length(aligned). Copper strips of adjacent eta region are offset by 2.5 mm on each side of the reference line. Thus there is a spacing of 5 mm between one set of strips of one eta region to another.

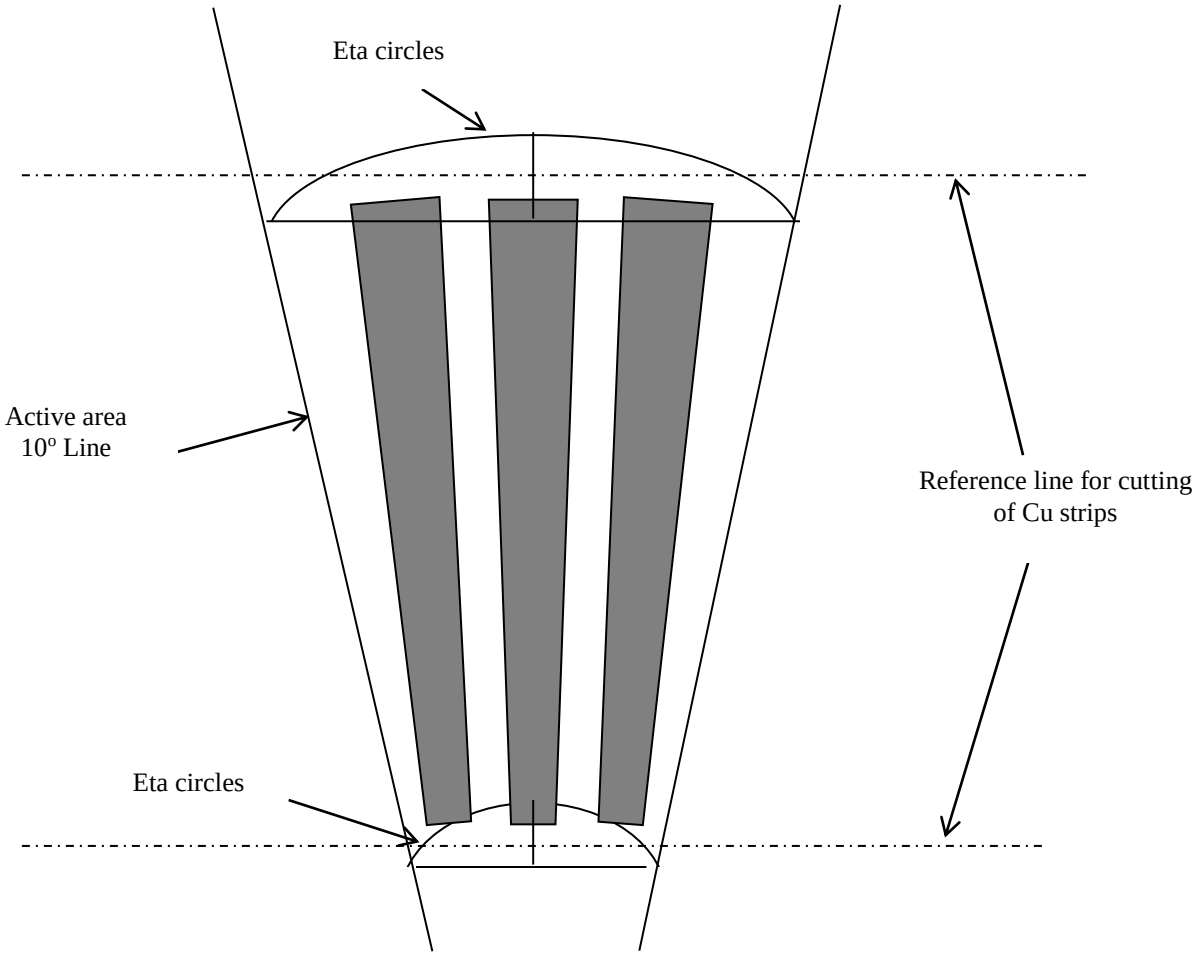


Fig. 7: Chamber strips division

Strip geometry for η segment a

	RE 1/1	RE 1/2	RE 1/3	RE 2/1	RE 2/2, 3/2, 4/2	RE 2/3, 3/3, 4/3	RE 3/1	RE 4/1
R i, mm	1377	2770	5085	1974	3313	5015	_	_
R o, mm	1595	3567	5630	2233	3793	5630	_	_
Height (D)	218	797.2	544.5	259.4	480	615	_	_
Major base (B)	6.7	17.5	28.7	10.2	18.7	28.7	_	_
Minor base (C)	5.5	13.1	25.7	8.8	16.1	25.4	_	_

Strip geometry for η segment b

	RE 1/1	RE 1/2	RE 1/3	RE 2/1	RE 2/2, 3/2, 4/2	RE 2/3, 3/3, 4/3	RE 3/1	RE 4/1
R i, mm	1600	3572	5635	2238	3798	5635	_	_
R o, mm	1804	4066	6397	2532	4346	6402	_	_
Height, (D)	205	494.1	762.5	293.7	548	768	_	_
Major base (B)	7.8	20.2	32.9	11.8	21.7	32.9	_	_
Minor base (C)	6.7	17.5	28.7	10.2	18.7	28.7	_	_

Strip geometry for η segment c

	RE 1/1	RE 1/2	RE 1/3	RE 2/1	RE 2/2, 3/2, 4/2	RE 2/3, 3/3, 4/3	RE 3/1	RE 4/1
R i, mm	1809	4071	6402	2537	4351	6407	2449	2669
R 0, mm	2054	4624	6800	2876	4972	6941	2876	2876
Height (D)	245	552.8	398	338.4	621	534	426.5	206.5
Major base (B)	9.2	23.2	35.1	13.7	25.1	35.9	13.7	13.7
Minor base (C)	7.9	20.2	32.9	11.8	21.7	33	11.4	12.6

Strip geometry for η segment d

	RE 1/1	RE 1/2	RE 1/3	RE 2/1	RE 2/2, 3/2, 4/2	RE 2/3, 3/3, 4/3	RE 3/1	RE 4/1
R i, mm	2059	-	-	2880	-	-	2880	2880
R o, mm	2382	-	-	3227	-	-	3227	3227
Height (D)	323	-	-	347	-	-	347	347
Major side (B)	11	-	-	15.6	-	-	15.6	15.6
Minor side (C)	9.2	-	-	13.7	-	-	13.7	13.7

Dimensions of chambers, full gap, cut gap, Active areas of full gap, cut gaps and strips are shown graphically in appendix A. Namely these are RE/1/1, RE /1/2, RE /1/3, RE /2/1, RE /3/1, RE /4/1, RE /*/2 and RE /*/3. (* = 2, 3, 4). RE/1/2 and RE/1/3 dimensions

Acknowledgement

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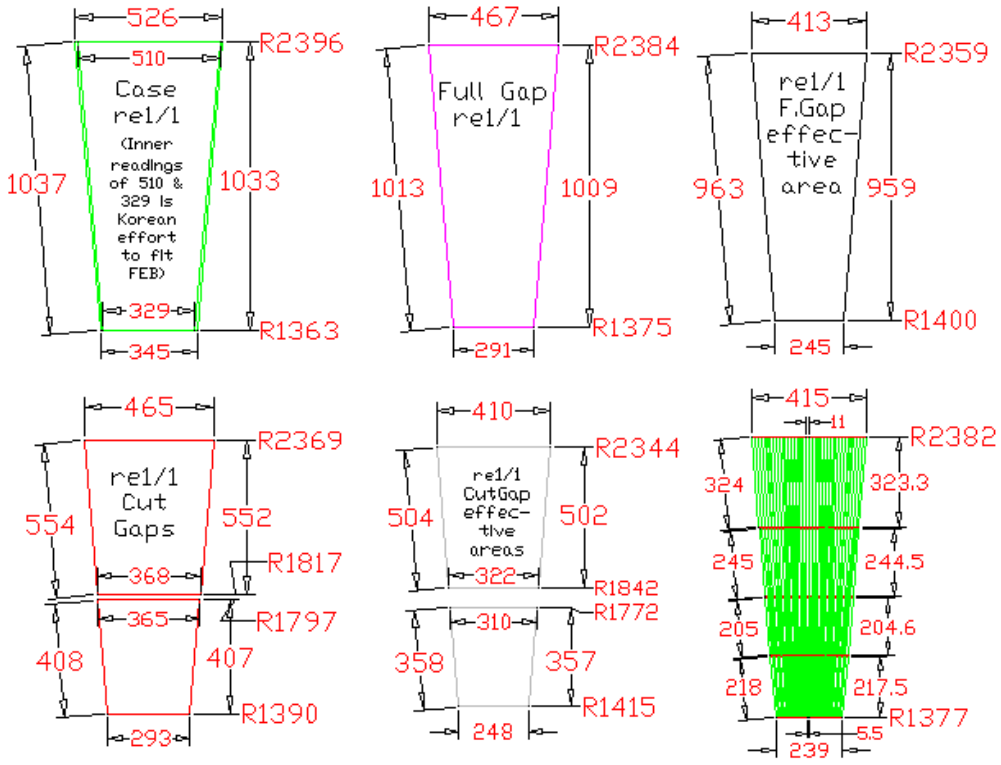
References

[1] Layout of the Link System for the RPC Pattern Comparator Trigger CMS NOTE 2000/xxx Draft. February 11, 2000.

[2] RPC System Geometry Simulated in CMSIM 118-120 and ORCA 4.2 CMS Internal Note 2000/054 November 09, 2000.

RE 1/1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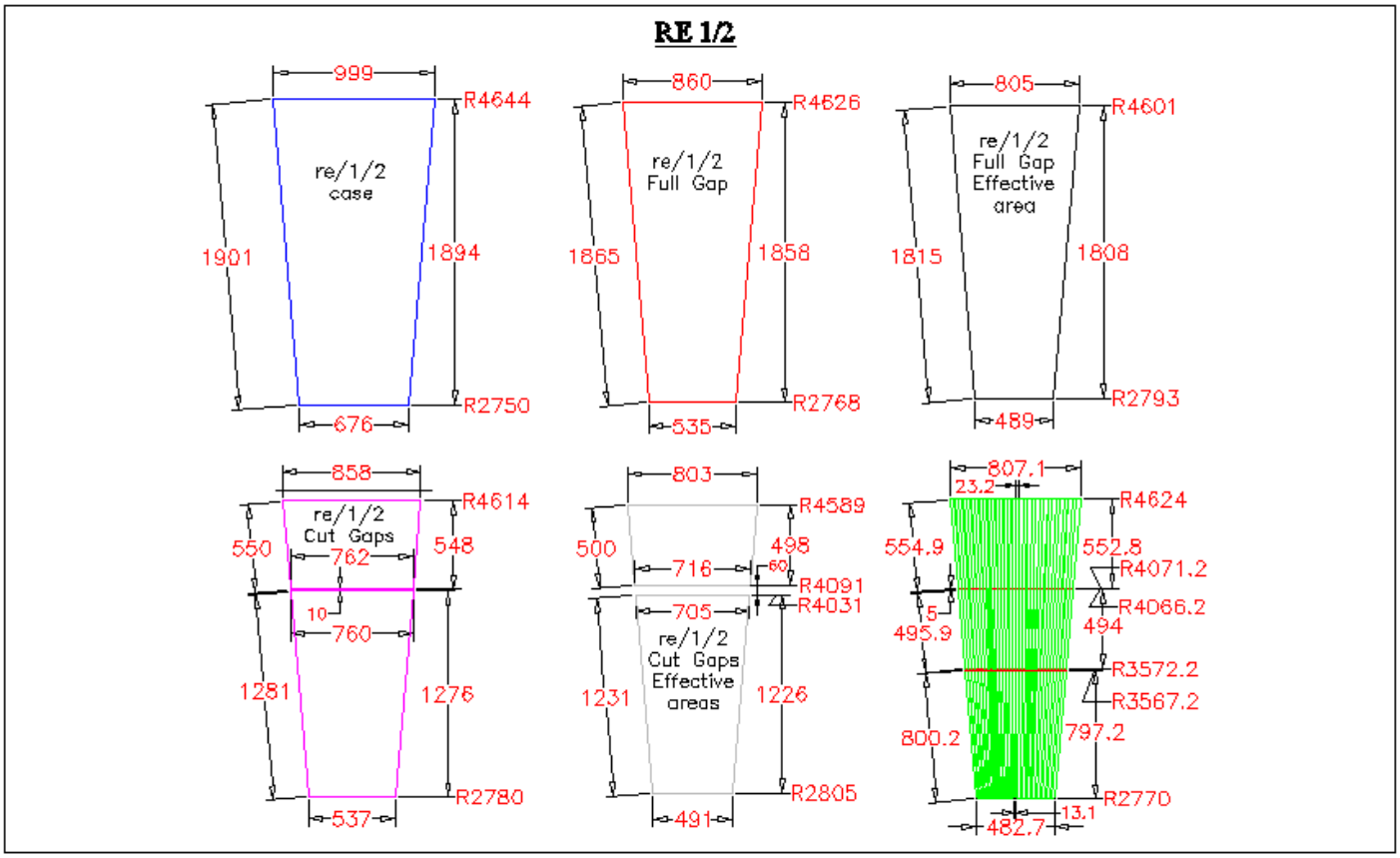
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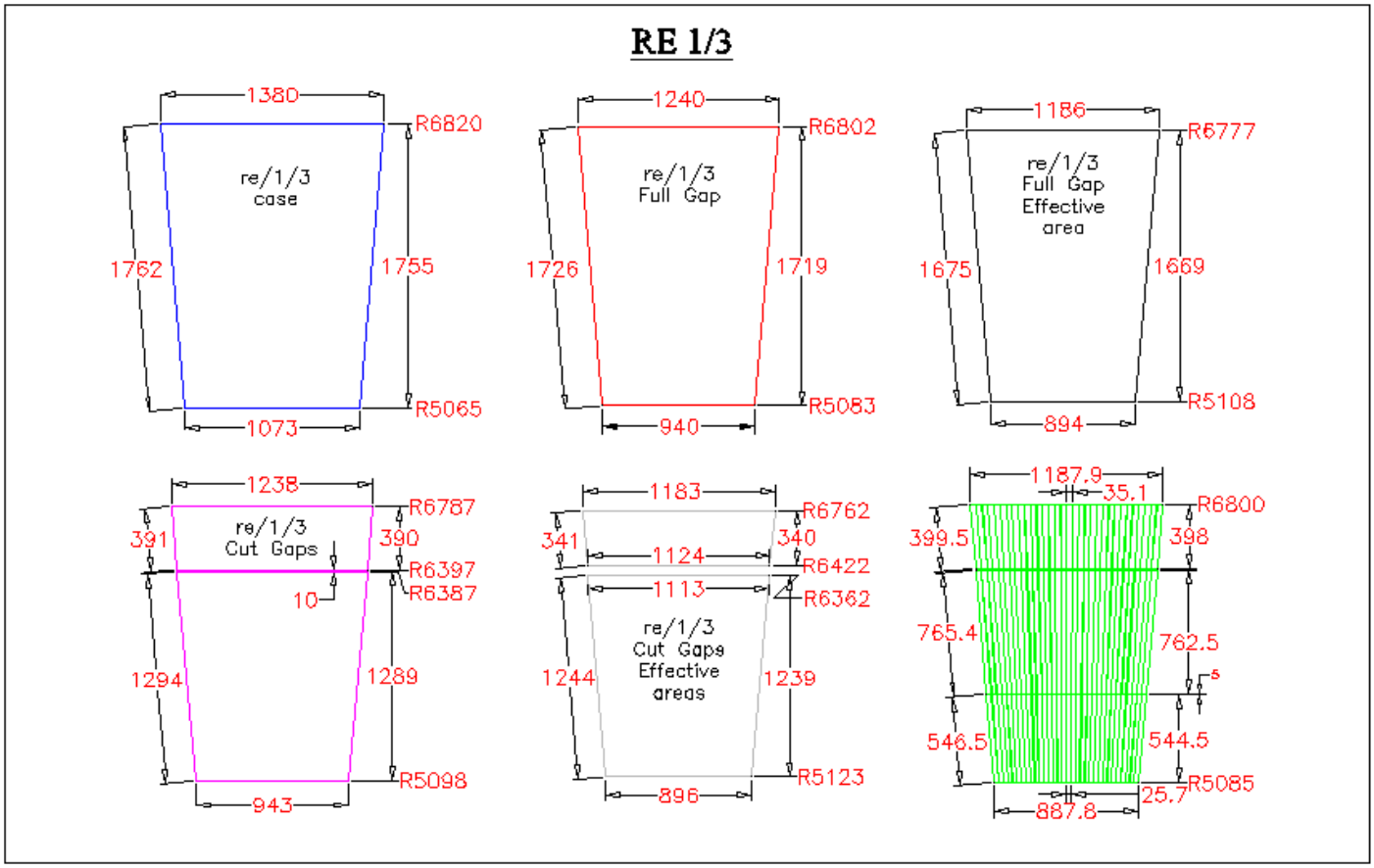
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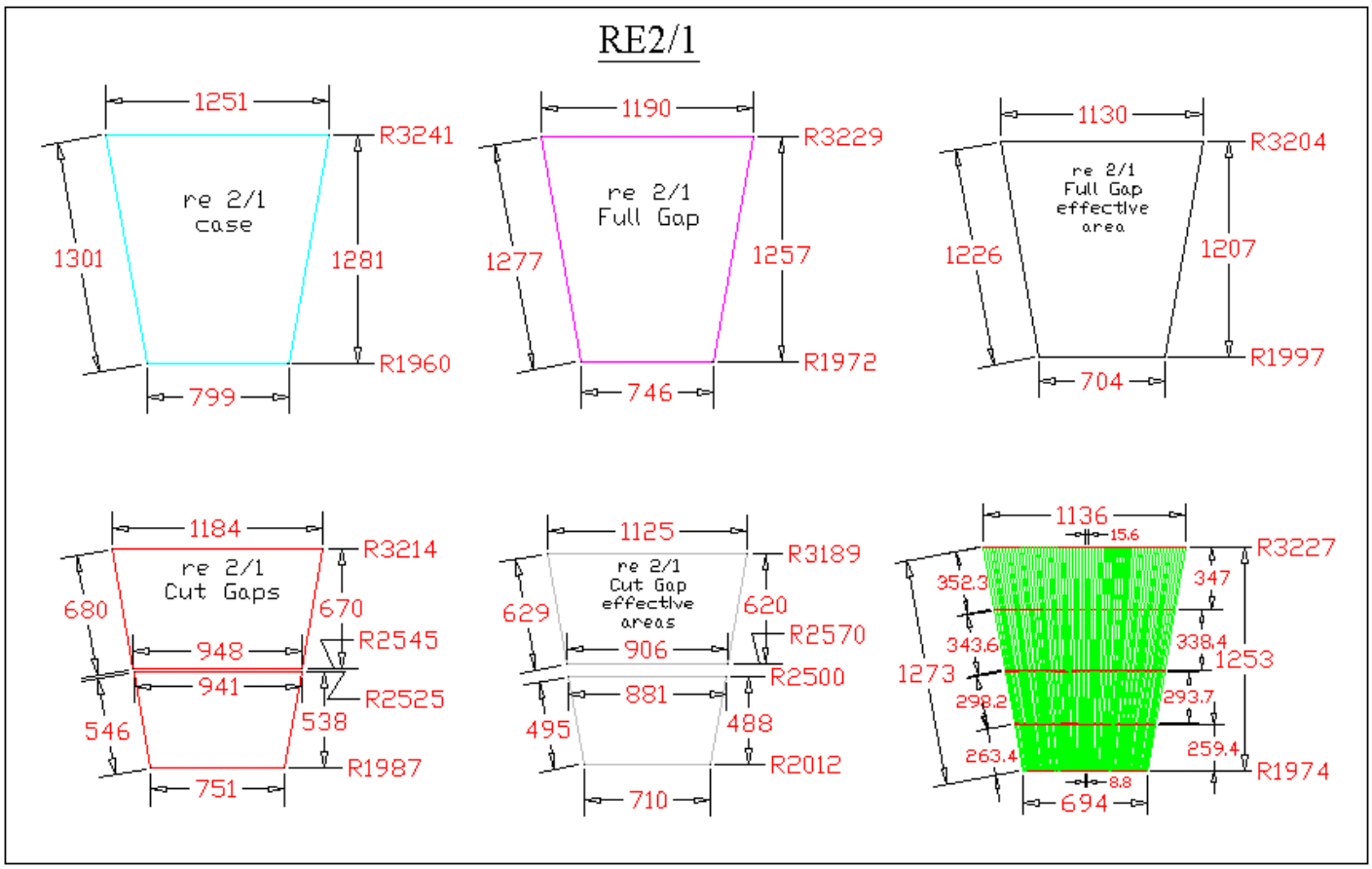
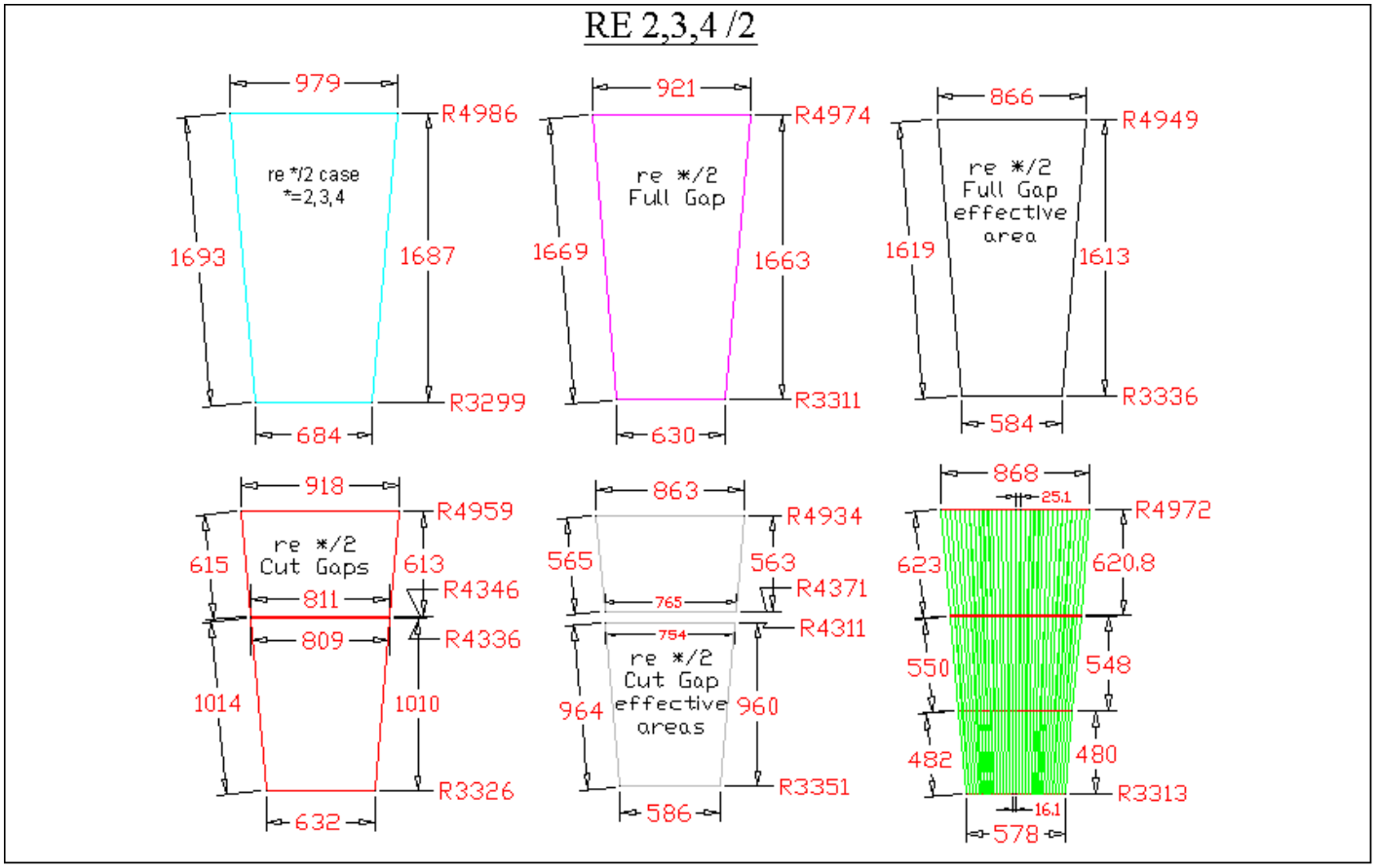
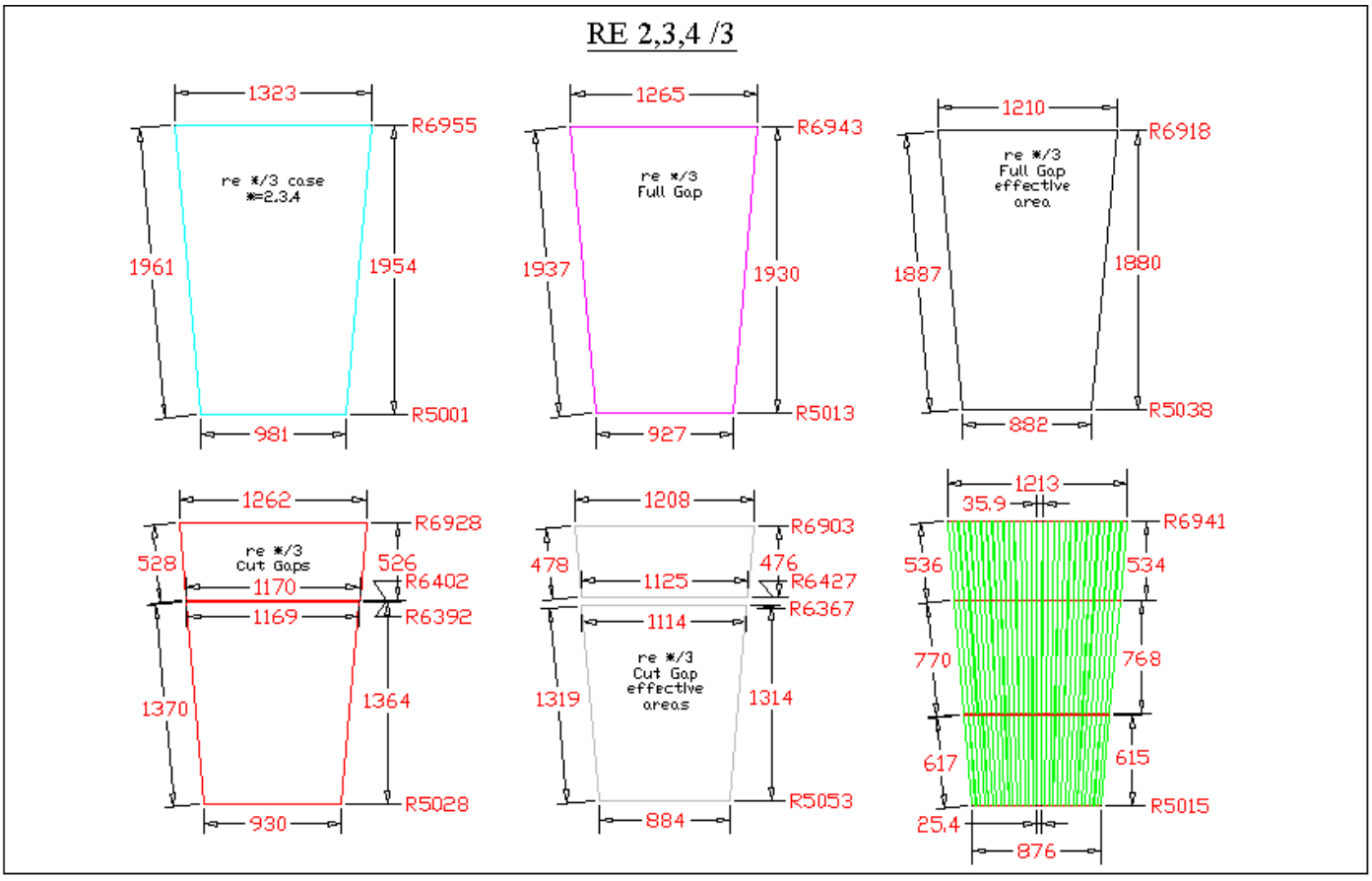
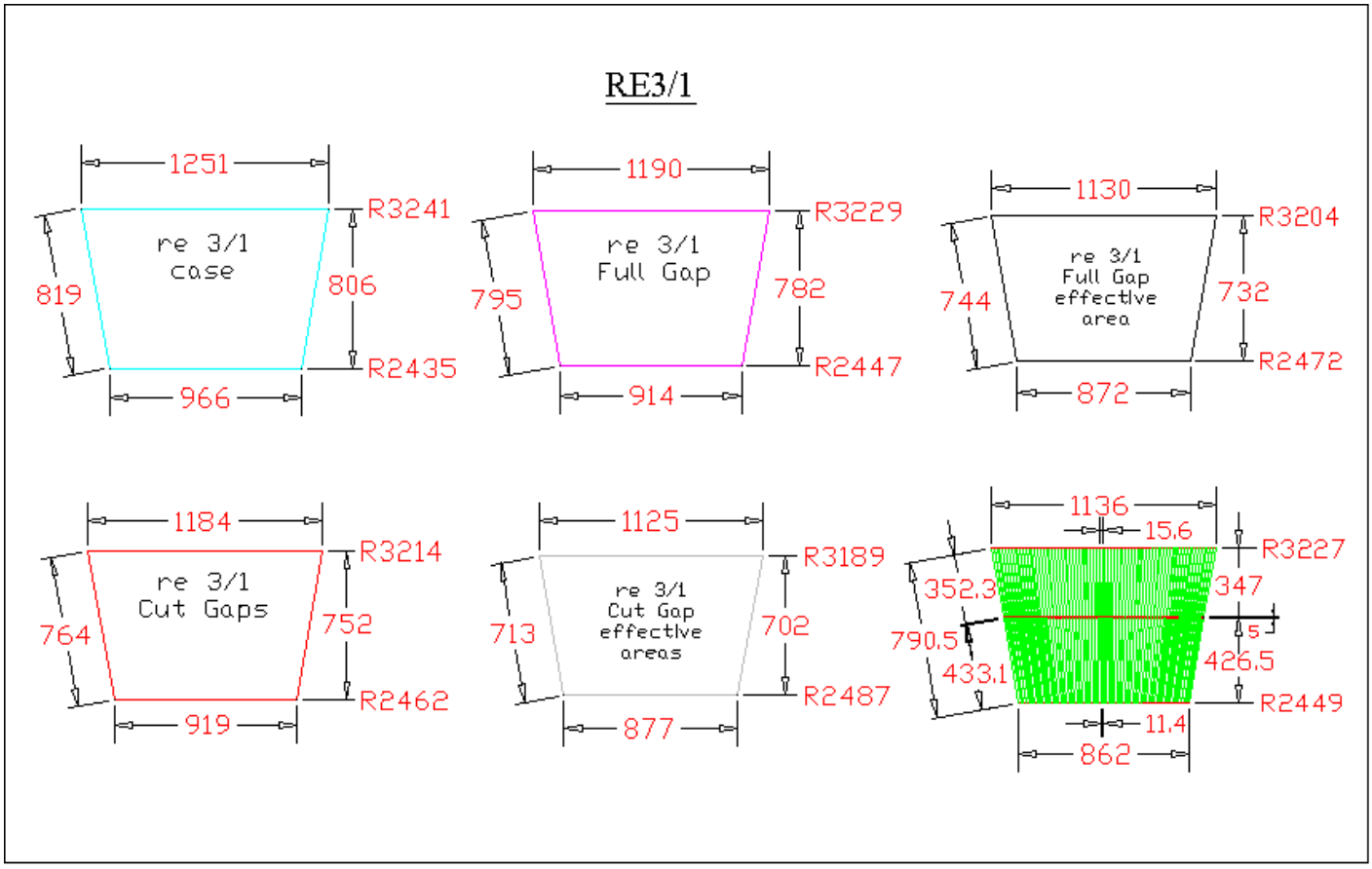
Full Gap
Effective
area
1675
1669
R5108
894
1238
R6787
391
re/1/3
Cut Gaps
390
R6397
10
R6387
1294
1289
R5098
943
1183
R6762
341
340
1124
R6422
1113
R6362
re/1/3
Cut Gaps
Effective
areas
1244
1239
R5123
896
1187.9
35.1
R6800
399.5
398
765.4
762.5
5
546.5
544.5
R5085
25.7
887.8


RE2/1
1251
R3241
re 2/1
case
1301
1281
R1960
799
1190
R3229
re 2/1
Full Gap
1277
1257
R1972
746
1130
R3204
re 2/1
Full Gap
effective
area
1226
1207
R1997
704
1184
R3214
re 2/1
Cut Gaps
680
670
948
R2545
941
R2525
546
538
R1987
751
1125
R3189
re 2/1
Cut Gap
effective
areas
629
620
906
R2570
881
R2500
495
488
R2012
710
1136
15.6
R3227
352.3
347
343.6
338.4
1253
1273
298.2
293.7
263.4
259.4
R1974
8.8
694

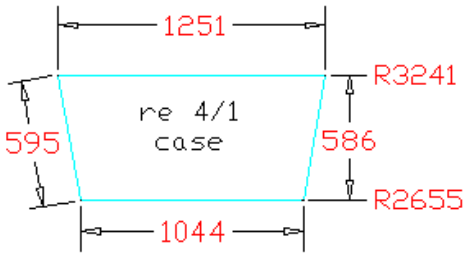

RE 2,3,4 /2
979
R4986
re */2 case
*=2,3,4
1693
1687
R3299
684
921
R4974
re */2
Full Gap
1669
1663
R3311
630
866
R4949
re */2
Full Gap
effective
area
1619
1613
R3336
584
918
R4959
re */2
Cut Gaps
615
613
811
R4346
809
R4336
1014
1010
R3326
632
863
R4934
565
563
765
R4371
754
R4311
re */2
Cut Gap
effective
areas
964
960
R3351
586
868
25.1
R4972
623
620.8
550
548
482
480
R3313
16.1
578

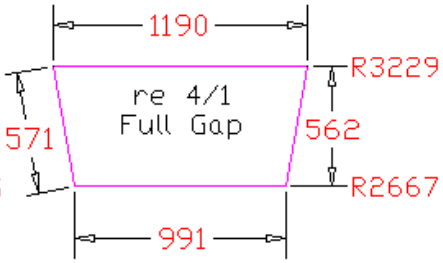

RE 2,3,4 /3
1323
R6955
re */3 case
*=2,3,4
1961
1954
R5001
981
1265
R6943
re */3
Full Gap
1937
1930
R5013
927
1210
R6918
re */3
Full Gap
effective
area
1887
1880
R5038
882
1262
R6928
re */3
Cut Gaps
528
526
1170
R6402
1169
R6392
1370
1364
R5028
930
1208
R6903
478
476
1125
R6427
1114
R6367
re */3
Cut Gap
effective
areas
1319
1314
R5053
884
1213
35.9
R6941
536
534
770
768
617
615
R5015
25.4
876

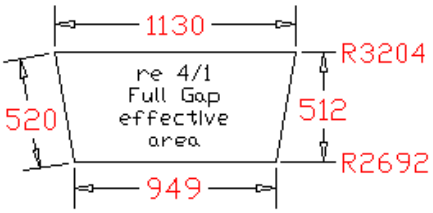


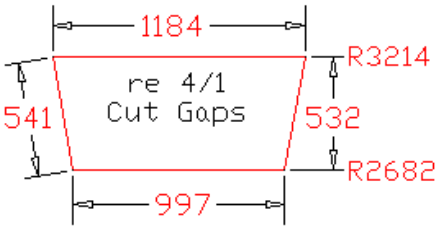
AT HIGH ETA OF RE/3/1 THE LOWEST ETA SEGMENT LENGTH EQUALED 131 MM (13.1 Centimeters). THIS SEGMENT HAS NOW BEEN MERGED WITH ONE ABOVE IT. ONE SEGMENT LESS TRANSLATES INTO 18 X 2 = 36 LESS FEB'S (64 X 36 = 2304 LESS CHANNELS) FOR HALF OF THE CMS. FOR BOTH + & - SIDES, IT IS 72 LESS FEBS, 4608 LESS CHANNELS.
IN CASE OF UNACCEPTABILITY OF THIS CHANGE, THE AUTHORS MAY BE NOTIFIED.

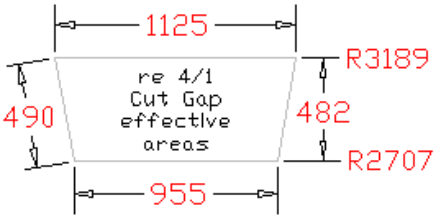
RE4/1

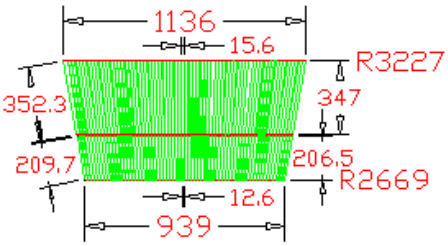

1251
R3241
re 4/1
case
595
586
R2655
1044


1190
R3229
re 4/1
Full Gap
571
562
R2667
991

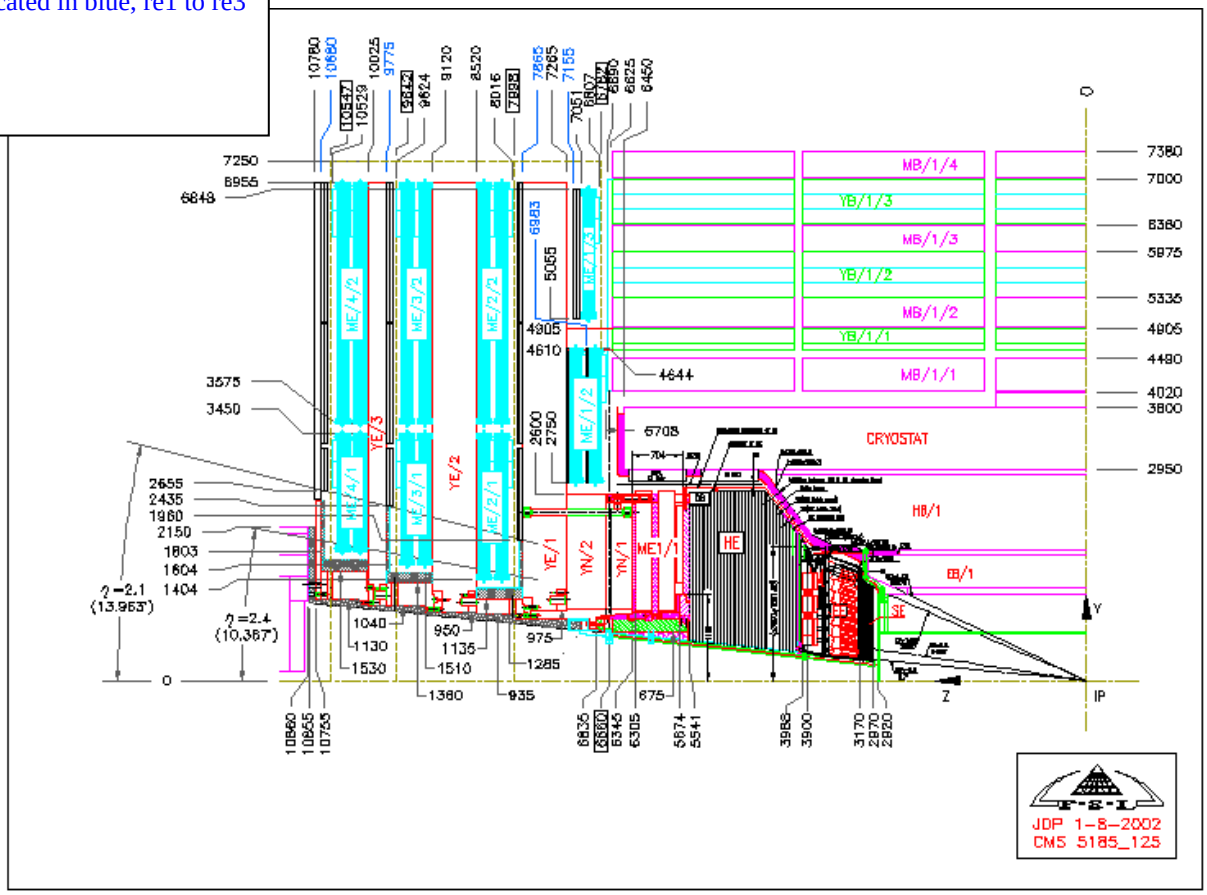

1130
R3204
re 4/1
Full Gap
effective
area
520
512
R2692
949

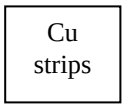

1184
R3214
re 4/1
Cut Gaps
541
532
R2682
997


1125
R3189
re 4/1
Cut Gap
effective
areas
490
482
R2707
955


1136
15.6
R3227
352.3
347
209.7
206.5
R2669
12.6
939

Rpc Z-positions are indicated in blue, re1 to re3




Cu
strips