TITLE: **Planck-LFI CPV: front end amplifier bias pre-tuning**
(Planck-LFI CPV: front end amplifier bias pre-tuning)

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CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
0.1	25 June 09	All	First draft issue	0.1
1.0	10 October 09	All	Minor revision of the document	1.0

TABLE OF CONTENTS

1 ACRONYMS

AIV	Assembly, Integration, Verification
ASW	Application Software
BEM	Back End Module
BEU	Back End Unit
CCS	Central Check-out System
CDMU	Central Data Management Unit
CPV	Calibration Performance Verification
CSL	Centre Spatiale de Liège
DAE	Data Acquisition Electronics
DPU	Digital Processing Unit
EGSE	Electrical ground Support Equipment
FEM	Front End Module
I-EGSE	Instrument EGSE
IST	Integrated Satellite Test
OBC	On Board Clock
RAA	Radiometer Array Assembly
REBA	Radiometric Electronic Box Assembly
S/C	Spacecraft
SCOE	Spacecraft Control and Operation System
SCS	Sorption Cooler System
SPU	Signal Processing Unit
SUSW	Start- Up Software
SVM	Service Module
TBC	To Be Checked
TBW	To Be Written
TC	Telecommand
TM	Telemetry
UFT	Unit Functional Test

2 APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable Documents

[AD1] Herschel/Planck Instrument Interface document Part A, SCI-PT-IIDA-04624 Issue 3.3

[AD2] Herschel/Planck Instrument Interface document Part B, SCI-PT-IIDB-04142 Issue 3.1

[AD3] Herschel/Planck Instrument Interface document Part B, SCI-PT-IIDB-04142 Issue 3.1, Annex 3, ICD 750800115

[AD4] Herschel/Planck Instrument Interface document Part A, SCI-PT-IIDA-04624 Issue 3.3 Annex 10

[AD5] Data analysis and scientific performance of the LFI FM instrument, PL-LFI-PST-AN-006 3.0

[AD6] Planck-LFI TV-TB test report: executive summary, PL-LFI-PST-RP-040 1.1

2.2 Reference Documents

[RD1] Planck Instrument Testing at PFM S/C levels, H-P-3-ASP-TN-0676, Issue 1.0

[RD2] Planck LFI User Manual, PL-LFI-PST-MA-001 Issue 2.1

[RD3] Data analysis and of LFI switch on and cryogenic functionality test (Ph-5-01-c of TV/TB tests) PL-LFI-PST-RP-036

[RD4] Change in bias tuning approach during the CPV phase after the CSL test campaign experience
PL-LFI-PST-TN-091

[RD5] Planck-LFI CPV: Hyper Matrix Tuning,
PL-LFI-PST-RP-06X

[RD6] TUNINING OF PLANCK-LFI LNAs IN CPV: REQUIREMENTS SPECIFICATION
PL-LFI-PST-SP-017

[RD7] Testing Plan of the LFI instrument during the Planck Commissioning and CPV phase
PL-LFI-PST-PL-013, Issue 4.3 (04-2009)

3 Introduction

This document describes the results from the Hypermatrix pre – tuning activities.

The Pre – Tuning is aimed at exploring the LNAs bias space changing simultaneously the four Vg bias powering each radiometer , in order to focus the bias region expected to provide the best performance. Noise Temperature is the figure of merit. It is measured roughly calculating Y factor basing on the sky – ref unbalancing over the same BEM diode when the 4KHz switching is enabled. Previous tests conducted on data from CSL campaign demonstrated that a good agreement between this rough calculation and the true Y-factor method (basing on two reference temperatures provided by the 4K stage *cooldown*) is achievable.

3.1 Test description

The test consisted in the simultaneous change of Vg1 Vg2 bias powering two paired ACAs , over several RCAs , grouped following the scheme:

GROUP 1: 18-19-22

GROUP 2: 20-21-23

GROUP 3: 24-26-28

GROUP 4: 25-27

Grouping is aimed at minimizing the bias cross talk effects along the harness lines. The conceptual scheme of the test is reported below.

<u>START CONDITION</u>: All radiometers on, powered with CRYO BIAS (optimal bias from CSL matrix tuning)

<u>Group 1:</u> Vg1 (ACA1) , Vg2 (ACA1), Vg1 (ACA2) , Vg2 (ACA2) from RCA 18, 19, 22 are changed in quadruplets; 784 bias quadruplets are exercised. Signal is integrated over 15 seconds for each quadruplet.

<u>Default cryo bias are restored</u>

At the end, the same is repeated changing Vg1 (ACA3) , Vg2 (ACA3), Vg1 (ACA4) , Vg2 (ACA4) over different 784 bias q1uadruplets.

<u>Default cryo bias are restored.</u>

<u>The same procedure is repeated for the next groups , one by one.</u>

The integration time per quadruplet changes with the group under test. It was set to 15 seconds for groups 1 and 2 , to 9 seconds for groups 3, and 4 (grouping 30 GHz and 44 GHz channels that show a shorter signal drift following a bias change).

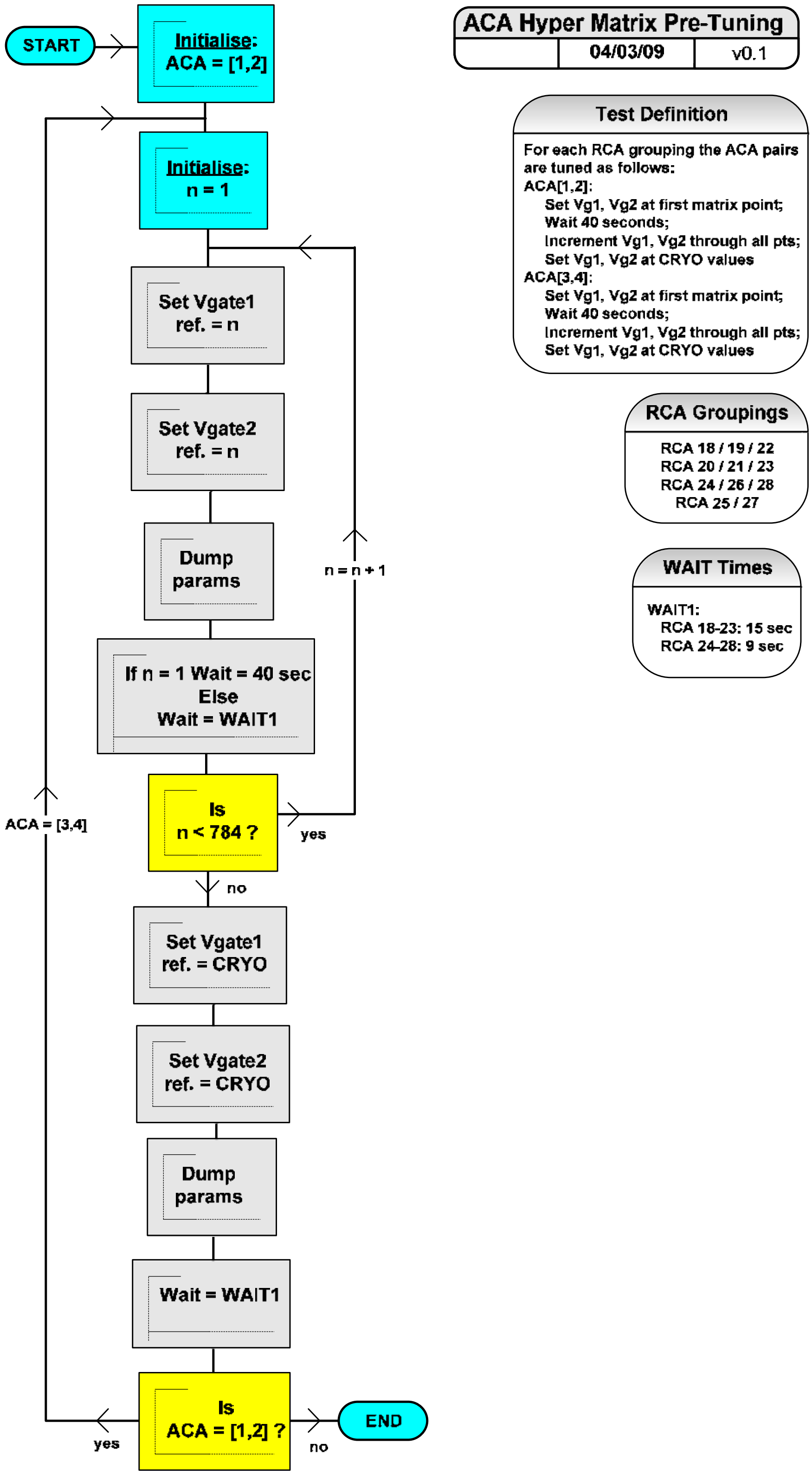


Figure 1Pre Tuning Test flow

3.2 Output

The test is expected to provide 4 dimensional maps of the noise temperature characterizing each radiometer. The whole 784 quadruplets bias space is mapped. Each map is analyzed in order to identify new bias regions formed by 625 quadruplets to be used as input for the Hyper Matrix Tuning .

The rules followed to produce the new matrixes are mainly two:

-Reduce the bias region where a clear minimum (in noise temperature) is evident.

- Extend the bias region where an out of boundaries region is supposed to contain a possible minimum.

Two examples are shown below

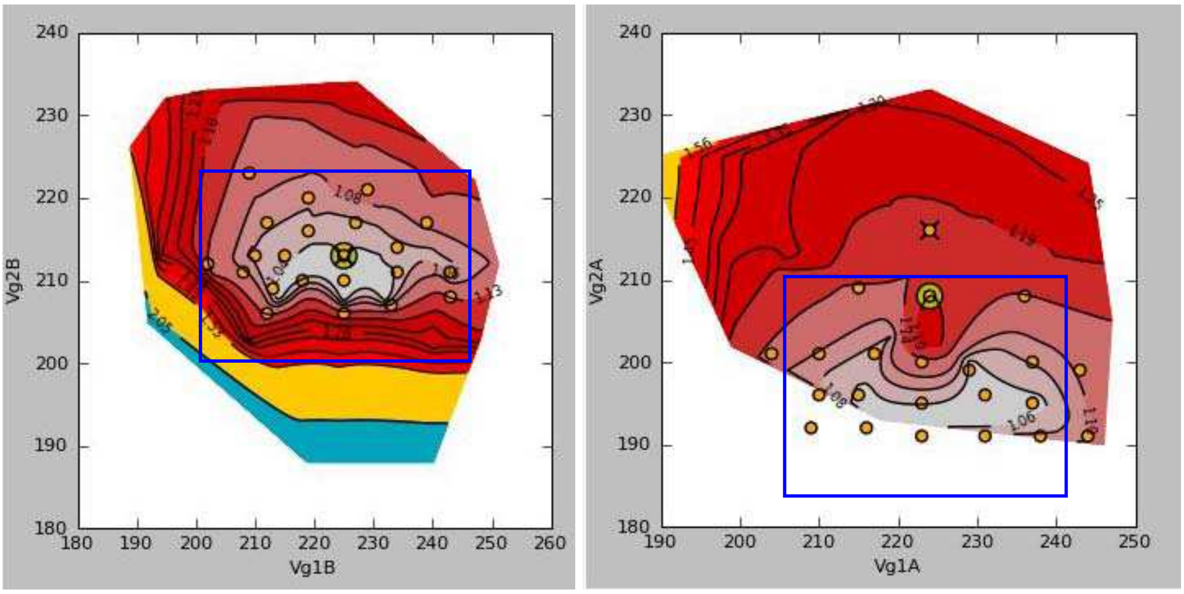


Figure 2 Noise temperature Vs Vg1 – Vg2 represented in a colour scale (normalized to the minimum of the noise temperature) ; in grey the best performance regions, in red and in yellow the higher noise temperature ,values higher than 50K in light blue. A clear minimum is visible in the left panel while a possible minimum outside the matrix boundaries is highlighted in the right panel.

The final output is composed by 22 Matrixes containing 625 quadruplets each.

3.3 Analysis and HYM matrix production.

The analysis is performed using two codes; the first is an IDL code running under LIFE, reading the FITS files, calculating the noise temperature and producing for each quadruplet change all the information needed for the analysis. A representative output is displayed in the fig below.

This output is ingested into a PYTON-based code able to display data, to select the reduced or extended bias regions , to resample the regions in order to get the exact number of points generating the 625 quadruplets used for the HYM Tuning.

The flow of the analysis is the following:

1) Run IDL code to find bias changes and calculate for each quadruplet the noise temperature over the two diodes, basing on the equations:

$$Tn = \frac{T_{ref} - Y \cdot T_{sky}}{Y - 1}$$

$$Y = \frac{V_{ref}}{V_{sky}}$$

A representative output is displayed in Figure 3 below.

```
vg1A  ,vg2A, vg1B, vg2B,   Tn1,     Tn2,       IdA,   IdB,   time

196,   185,   201,   155,   33.398,  33.248,    12.13, 17.12, 1623858171.65

196,   185,   201,   164,   32.560,  32.963,    12.12, 17.98, 1623858189.65

200,   192,   201,   164,   31.495,  31.817,    13.55, 17.95, 1623858207.65

200,   192,   192,   165,   30.727,  31.174,    13.55, 16.35, 1623858225.65

203,   99,    192,   165,   31.681,  31.981,    14.91, 16.32, 1623858243.65

198,   209,   192,   165,  32.049,  32.334,     15.82, 16.31, 1623858261.65

……………………………………………………………………………………………
```

Figure 3 typical output from the Pre Tuning analysis

2) display the noise temperatures using the PYTON code ; the code allows to display two dimensional cuts of changes over ACA 1 and ACA 2 but, just selecting the desired point, is possible to display performance calculated for each Vg1 (ACAi), Vg2 (ACAi), Vg1 (ACAj), he Vg2 (ACAj) ,combination. . For each cut also the drain current in the same bias space can be displayed, in order to seek for the best LNAs Gain balancing when selecting the points.

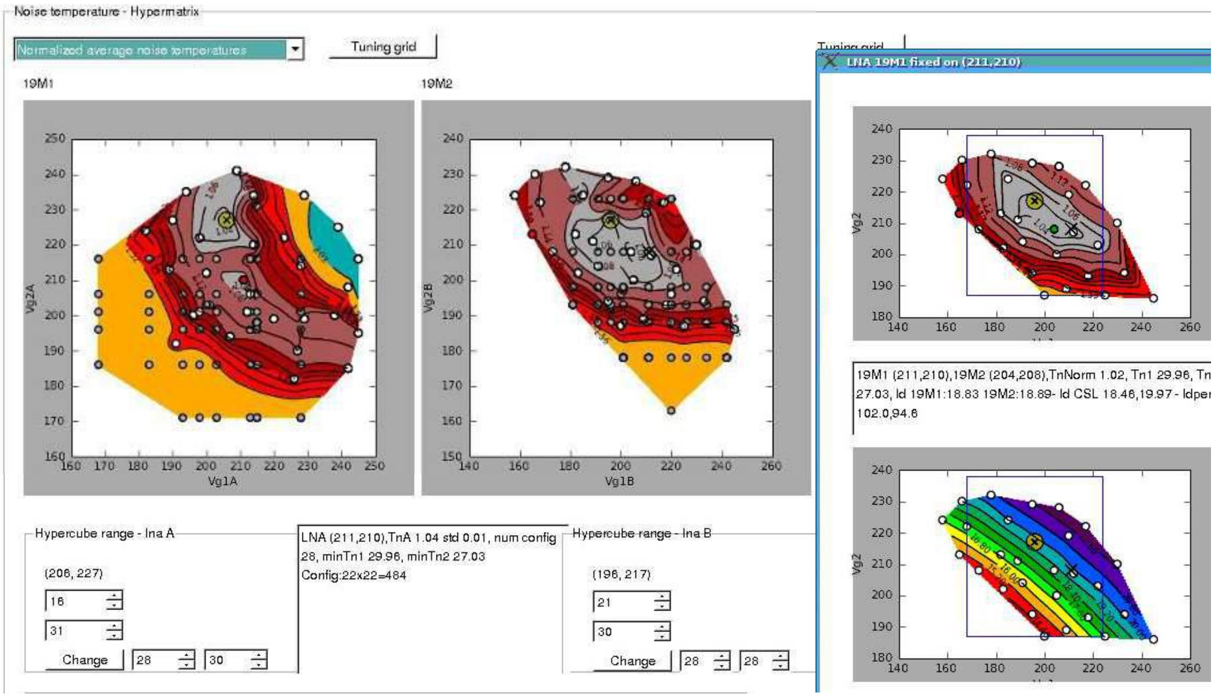
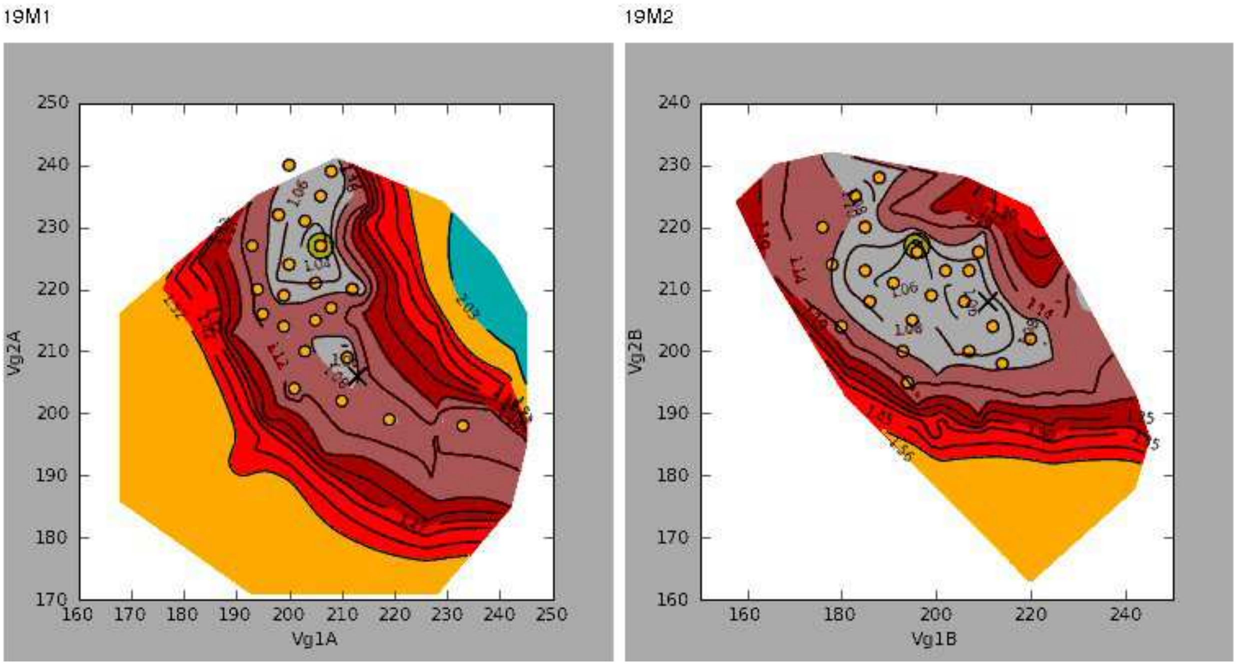


Figure 4

3) choose the bias regions of interest (also expanding boundaries outside the previous range) and re-sample them by using 22 points per ACA (producing 484 combinations) .



4) produce n=22 625 points matrix (one per radiometer) containing each :

484 re-sampled quadruplets

50 quadruplets (25+25) with the lowest noise temperature exercised during matrix tuning performed in CSL (2008)

6 special quadruplets (optimal tuned bias coming from Tuning at FEM, RCA, RAA before and after tuning, CSL, Drain Current verification (performed in CPV))

The 75 quadruplets exhibiting the lowest noise temperature.

10 points are left empty to be used by the module ordering quadruplets, as explained at point 4.

5) order the quadruplets by minimizing the total bias jump using a routine implemented inside the Python code (based on the SQRT (Vg1^2+Vg2^2+Vg1^2+Vg2^2)). This is done do avoid possible signal drifts due to the bias changes that were demonstrated to be directly proportional to the height of the bias change. In the 10 worst cases the integration time is doubled by advantaging of the available 10 points remained unused to fill the 625 pts matrix.

4 Test Execution

The test started on OD33 (June 16th at 10.30 UTC) and run until OD 35 (June 17th at 12.47)

4.1 Test configuration

The test configuration is the following

SCOS 2 K HPCCS Version 2.0.787
LFI Gateway Version V0R9P1
TQL 3.1.2
LIFE Machine version OM 3.00

LFI Personnel involved during the test is:

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Industry support	Paola Battaglia

4.2 Pass - fail criteria, verification matrix

CPV	**P_PVP_LFI_0005_01**
June, xx 2009 xx:xxz	**DoY 1xx OD ss**
Duration	**xx:xx:00**
Test name:	**ACA hyper matrix pre-tuning**
Test objectives:	The scope of this test is to check the optimisation of the radiometer noise temperature by tuning the Vg1 and VG2 of every LNA for each channel. Given the two radiometer channels M1 and M2, when tuning channel M1 (Vg1,Vg2), channel M2 (which is coupled to channel M1 through the two hybrids) is still on with (Vg1,Vg2) nominal value set. Channels S1 and S2 are on, in order not to impact on the overall power dissipation on the FPU thus affecting its temperature stability. The procedure is repeated for all other instrument channels. To speed up the execution of the procedure the sequence is build in order to perform the tuning in two different ACAs in parallel. The chosen ACAs are belonging to different power groups in order to minimize the coupling between radiometers biases.

Verification matrix					
Check	Passed?			Recovered?	
	Yes	No	Notes	Yes	No
No unexpected event Packets					
TC procedure					
Every ACA is responding to Biases stimulus as expected					
No unexpected features					
Data saved and stored at DPC					

4.3 Procedure/ Test sequence and environmental conditions

4.3.1 Test procedure

The test procedure (serving also as a checklist) is summarized in APPENDIX1

4.3.2 Temperatures

The temperatures of sensors relevant for this test are reported in the three following plots. The test was executed during the 4K cooler cool-down, starting when the 4K load was around **21.2K**. the requirement was to perform the test between 25K and 22K: however this difference does not affect the validity of the test.

The average temperature change measured during the whole test was around **26mK/hr** (Req. <40 mK/hr). In Figure 5 the 4K fluctuation generated by the SCS (strongly coupled because of the 4K stage thermal setup before the cooldown from 18K to 4K) are evident.

The FPU (blue trace in Figure 6) looks instead very stable, as well as the sensors in the BEU on the DAE (Figure 7) . Thermal conditions were hence compliant with requirements and considered suitable for the test execution.

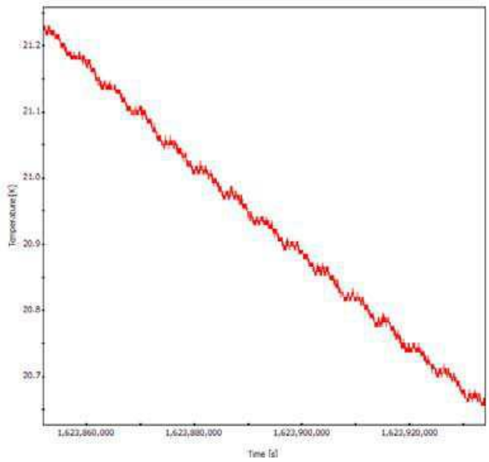


Figure 5   4K temperature during Pre Tuning

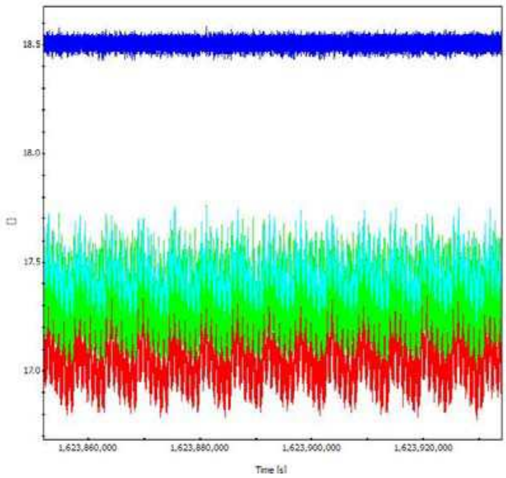


Figure 6 LFI front-end unit temperature during the Pre-Tuning

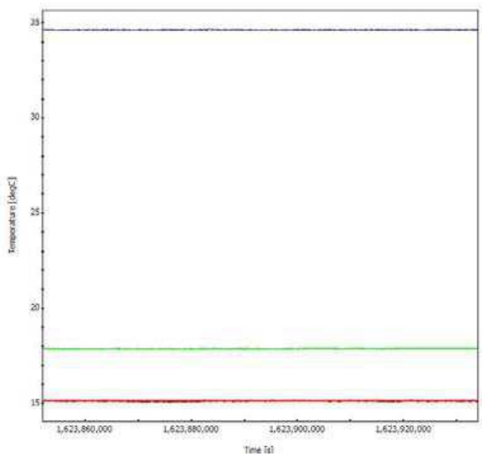


Figure 7 BEU temperatures during the Pre-Tuning

4.3.3 Default bias

The bias used as default (set on channels not under test) are those resulting from Tuning in CSL, with the exception of the drain voltage set on RCA 24 M1 that was reduced from 200 DEC to 183 DEC in order to achieve a better LNAs balancing.

					vg1		vg2		vd		I1		I2	
CH27	00	00	M1	LP001320	240	F0	108	6C	156	9C	178	B2	180	B4
CH27	01	01	M2	LP002320	244	F4	90	5A	157	9D	144	90	214	D6
CH27	02	10	S1	LP003320	237	ED	102	66	157	9D	138	8A	192	C0
CH27	03	11	S2	LP004320	246	F6	114	72	156	9C	128	80	200	C8
CH24	04	00	M2	LP005320	227	E3	213	D5	183	B7	91	5B	255	FF
CH24	05	01	M1	LP006320	219	DB	217	D9	183	B7	128	80	250	FA
CH24	06	10	S2	LP007320	225	E1	213	D5	152	98	86	56	215	D7
CH24	07	11	S1	LP008320	219	DB	219	DB	157	9D	84	54	235	EB
CH21	08	00	S2	LP009320	216	D8	223	DF	132	84	255	FF	255	FF
CH21	09	01	S1	LP010320	181	B5	197	C5	136	88	255	FF	255	FF
CH21	0A	10	M1	LP011320	198	C6	207	CF	141	8D	255	FF	255	FF
CH21	0B	11	M2	LP012320	196	C4	197	C5	136	88	255	FF	255	FF
CH22	0C	00	S2	LP013320	206	CE	204	CC	130	82	255	FF	255	FF
CH22	0D	01	S1	LP014320	204	CC	189	BD	128	80	255	FF	255	FF
CH22	0E	10	M1	LP015320	203	CB	194	C2	125	7D	255	FF	255	FF
CH22	0F	11	M2	LP016320	178	B2	176	B0	130	82	255	FF	255	FF
CH23	10	00	S2	LP017320	190	BE	208	D0	122	7A	255	FF	255	FF
CH23	11	01	S1	LP018320	181	B5	211	D3	118	76	255	FF	255	FF
CH23	12	10	M1	LP019320	207	CF	192	C0	120	78	255	FF	255	FF
CH23	13	11	M2	LP020320	210	D2	195	C3	119	77	255	FF	255	FF
CH25	14	00	M1	LP021320	227	E3	212	D4	184	B8	174	AE	235	EB
CH25	15	01	M2	LP022320	219	DB	212	D4	185	B9	89	59	250	FA
CH25	16	10	S1	LP023320	224	E0	216	D8	167	A7	93	5D	255	FF
CH25	17	11	S2	LP024320	223	DF	212	D4	166	A6	119	77	225	E1
CH28	18	00	M1	LP025320	243	F3	101	65	157	9D	132	84	162	A2
CH28	19	01	M2	LP026320	240	F0	112	70	156	9C	117	75	188	BC
CH28	1A	10	S1	LP027320	240	F0	84	54	157	9D	111	6F	168	A8
CH28	1B	11	S2	LP028320	245	F5	121	79	158	9E	99	63	173	AD
CH20	1C	00	S2	LP029320	188	BC	201	C9	127	7F	255	FF	255	FF
CH20	1D	01	S1	LP030320	199	C7	221	DD	132	84	255	FF	255	FF
CH20	1E	10	M1	LP031320	209	D1	219	DB	121	79	255	FF	255	FF
CH20	1F	11	M2	LP032320	215	D7	221	DD	127	7F	255	FF	255	FF
CH19	20	00	S2	LP033320	204	CC	216	D8	125	7D	255	FF	255	FF
CH19	21	01	S1	LP034320	215	D7	209	D1	120	78	255	FF	255	FF
CH19	22	10	M1	LP035320	213	D5	206	CE	124	7C	255	FF	255	FF
CH19	23	11	M2	LP036320	211	D3	208	D0	126	7E	255	FF	255	FF
CH18	24	00	S2	LP037320	208	D0	205	CD	114	72	255	FF	255	FF
CH18	25	01	S1	LP038320	192	C0	197	C5	138	8A	255	FF	255	FF
CH18	26	10	M1	LP039320	190	BE	194	C2	126	7E	255	FF	255	FF
CH18	27	11	M2	LP040320	198	C6	201	C9	125	7D	255	FF	255	FF
CH26	28	00	M2	LP041320	226	E2	217	D9	170	AA	153	99	210	D2
CH26	29	01	M1	LP042320	232	E8	209	D1	169	A9	98	62	245	F5
CH26	2A	10	S2	LP043320	232	E8	217	D9	169	A9	93	5D	230	E6
CH26	2B	11	S1	LP044320	228	E4	226	E2	172	AC	135	87	230	E6

					G		O	
CH27	00	00	M1	LP001320	0	0	21	15
CH27	01	01	M2	LP002320	0	0	0	0
CH27	02	10	S1	LP003320	0	0	51	33
CH27	03	11	S2	LP004320	0	0	50	32
CH24	04	00	M2	LP005320	0	0	255	FF
CH24	05	01	M1	LP006320	0	0	255	FF
CH24	06	10	S2	LP007320	0	0	255	FF
CH24	07	11	S1	LP008320	0	0	255	FF
CH21	08	00	S2	LP009320	0	0	194	C2
CH21	09	01	S1	LP010320	0	0	204	CC
CH21	0A	10	M1	LP011320	0	0	180	B4
CH21	0B	11	M2	LP012320	0	0	180	B4
CH22	0C	00	S2	LP013320	0	0	255	FF
CH22	0D	01	S1	LP014320	0	0	255	FF
CH22	0E	10	M1	LP015320	0	0	255	FF
CH22	0F	11	M2	LP016320	0	0	255	FF
CH23	10	00	S2	LP017320	0	0	100	64
CH23	11	01	S1	LP018320	0	0	100	64
CH23	12	10	M1	LP019320	0	0	180	B4
CH23	13	11	M2	LP020320	0	0	180	B4
CH25	14	00	M1	LP021320	0	0	255	FF
CH25	15	01	M2	LP022320	0	0	255	FF
CH25	16	10	S1	LP023320	0	0	255	FF
CH25	17	11	S2	LP024320	0	0	255	FF
CH28	18	00	M1	LP025320	0	0	60	3C
CH28	19	01	M2	LP026320	0	0	41	29
CH28	1A	10	S1	LP027320	0	0	60	3C
CH28	1B	11	S2	LP028320	0	0	143	8F
CH20	1C	00	S2	LP029320	0	0	128	80
CH20	1D	01	S1	LP030320	0	0	128	80
CH20	1E	10	M1	LP031320	0	0	128	80
CH20	1F	11	M2	LP032320	0	0	128	80
CH19	20	00	S2	LP033320	0	0	214	D6
CH19	21	01	S1	LP034320	0	0	204	CC
CH19	22	10	M1	LP035320	0	0	220	DC
CH19	23	11	M2	LP036320	0	0	224	E0
CH18	24	00	S2	LP037320	0	0	0	0
CH18	25	01	S1	LP038320	0	0	0	0
CH18	26	10	M1	LP039320	0	0	128	80
CH18	27	11	M2	LP040320	0	0	128	80
CH26	28	00	M2	LP041320	0	0	255	FF
CH26	29	01	M1	LP042320	0	0	255	FF
CH26	2A	10	S2	LP043320	0	0	255	FF
CH26	2B	11	S1	LP044320	0	0	255	FF

Figure 8 default CRYO bias table applied for the test

4.4 Results and Conclusions

The procedure was successfully run without any problem. All the bias effectively applied were verified to be compliant with the input matrixes.

For all the 22 radiometers it was possible to identify the minimum noise temperature regions and to produce the sampling of 22 X 22 points. In order to avoid possible errors committed by the automatic routine (sometimes unable to cover with a good accuracy the best noise temperature regions) we preferred to sample regions by hands, mostly filling the best noise temperature contour levels.

All the 22 Matrixes to be used as input for the HYPER MATRIX Tuning have been produced.

In Add, several consistency checks have been performed on the PRE-Tuning data, in order to have a further confirmation of the method : they are described in the next paragraphs.

Comparison with the CSL results demonstrated that CSL performance were a sub-sample of the hyper matrix tuning, in agreement with performance foreseen by the Hyper Matrix Analysis.

Pre Tuning analysis was also applied to the 1st run of the hyper matrix tuning, showing that performance showed by the re-sampled hyper bias regions are in agreement with those from the pre tuning run. This is important because it confirms that radiometers do not suffer abrupt changes in performance when bias are changed slightly in the four dimensional space.

4.4.1 Consistency with Hyper Matrix Tuning 1st step.

Data from the 1st step of the HYM Tuning were analyzed basing on the same philosophy of the Pre Tuning . Results from the two runs have been compared, in order to seek for possible distortions of the noise temperature surface (w.r.t. the Pre Tuning results) due to the bias mixing generated by the re-sampling operation. Comparison is presented in APPENDIX 2 and shows that the bias regions resulting from the 1st step TUN analysis maintain the same shape of those from PRE Tuning analysis. Moreover, a numerical check was done on the quadruplets (from 130 to 150 depending on the channel) common to both runs. Results show a very good agreement over all the values, with very slight differences smaller than 1K in all the cases.

Pre tuning analysis applied to the 1st Tuning step gave results shown in Table 1: all quadruplets are contained in the regions describing minima in the Pre Tuning contour plots, sometimes slightly displaced respect to the previous localization: despite the Pre tuning intrinsically consists in a rough determination of the absolute noise temperature, results can be considered a good indication that the Tuning matrixes (derived from Pre Tuning analysis) are well drawn and seem able to resolve some minima that were unclear in the wider bias range space of the Pre Tuning input.

4.4.2 Analysis of the signal drift

The analysis of scientific signal from the 1st Step of HYM Tuning gives us an indication that the quadruplets was well ordered: actually no relevant signal drifts are evident due to the bias change. Moreover, the scientific signal is integrated over only three seconds for each bias set, discarding the last 4 seconds (just before the next bias step, to avoid misleading integrations due to possibly delayed triggers from the bias change acknowledge from DAE) for all the channels and the first 8 (30 GHz, 44 GHz) or 13 (70 GHz) (to cut off the increasing current region when a new bias quadruplet is applied) .

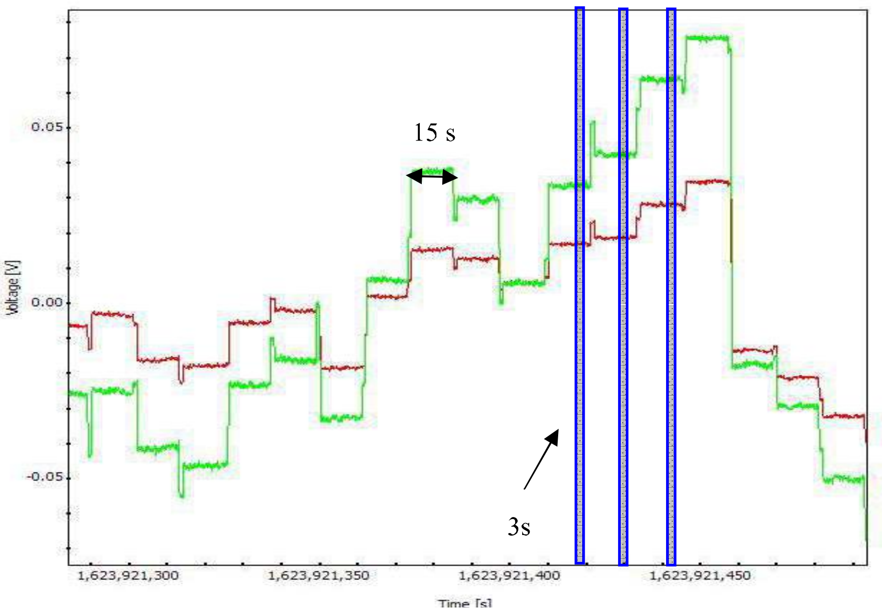


Figure 9 scientific signal from channel RCA 27-00 during HYM Tuning step 1: The total duration of each step (15 s) and the integration time (3 s) are highlighted.

RCA #	Vg1 (M1/S1)	Vg2 (M1/S1)	Vg1 (M2/S2)	Vg2 (M2/S2)	Tn1	Tn2	Id1	Id2	Id (CSL)1	Id(CSL)2
18M	199	187	195	205	28.79	28.46	13.34	14.4	13.62	14.53
18S	155	215	217	187	23.35	30.59	16.12	19.75	19.92	21.49
19M	206	227	207	213	29.82	26.54	21.24	20.22	18.46	19.97
19S	206	226	215	221	28.32	32	18.12	18.85	17.97	17.27
20M	191	244	209	231	30.05	30.31	21.35	21.29	20.72	20.81
20S	185	232	170	225	34.42	33.95	18.86	18.81	19.02	18.71
21M	191	230	191	223	23.27	26.36	20.87	23.55	18.86	20
21S	180	212	201	250	31.3	34.09	18.94	22.8	16.68	20.49
22M	207	204	190	192	28.67	29.94	16.01	17.06	14.39	15.04
22S	205	222	191	225	32.81	36.23	20.09	17.74	16.83	15.62
23M	206	202	190	228	32.32	27.58	15.87	17.26	14.93	14.35
23S	184	219	193	213	31.62	30.92	21.84	17.02	20.75	14.97
24M	226	204	227	204	20.76	18.87	7.86	7.25	14.45	10.05
24S	218	207	225	208	20.64	20.83	8.3	7.8	12.96	9.98
25M	223	203	218	200	20.79	20.25	6.63	7.11	9.21	9.83
25S	231	196	223	199	16.8	17.22	6.03	5.94	11.12	9.49
26S	238	194	228	196	18.33	19.07	7.01	5.05	13.43	10.46
27M	252	80	236	84	14.99	15.08	7.48	7.81	7.28	8.2
27S	238	86	255	93	16.52	15.16				
28M	246	195	237	156	19.03	19.26	9.81	10.82	9.7	9.22
28S	235	87	255	112	17.87	16.64	10.8	8.8	10.5	9.13

Table 1optimal bias from HYM tuning step 1 . Noise temperature is calculated advantaging of the unbalancing sky-ref over the same BEM diode

4.4.3 Drain currents model

Pre Tuning matrixes were drawn before launch basing on a model describing also the drain currents corresponding to each Vg bias change (quadruplet) . Results from I-V curves characterization tests applied to the Pre Tuning matrixes showed that the model was correct, and the measured drain currents are in full agreement with the prevision.

4.5 Non nominal features

Nothing worth of noting was observed during the test , as well as after the data analysis.

As reported in 4.3.2 , the 4K reference Load temperature was not nominal when the test started. However this requirement (25K > 4K_T > 22 K) was set only in the purpose of having the largest dynamic in the thermal range for the further steps of the HYM Tuning. Hence, being the startup temperature related with the 4K cooldown profile and with the Planck timeline, the thermal condition was accepted ‘as is’ without any consequence for this test.

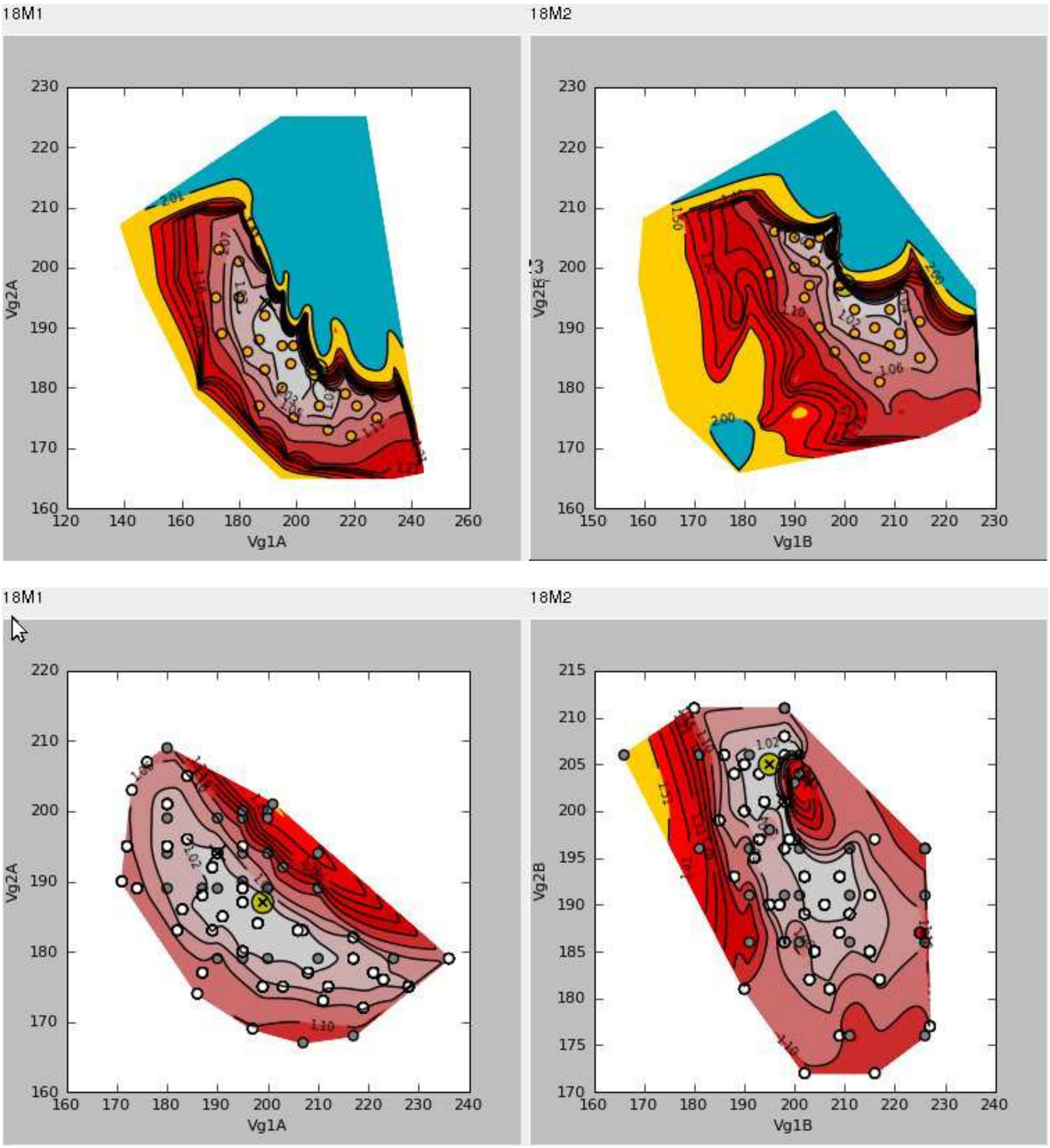
5 Appendix 1 – TEST PROCEDURE

	ACA Hyper Matrix Pre-Tuning			
	Detailed Description	Tuning of all 44 ACA channels		
	Constraints	Start Reference Temperature: **SCS TSA can also not be tuned yet. 4K Reference Load temperature stable within 40 mK@25K<T<22K. Phase shifters can also be not already tuned. 4KHz enabled. Procedure to be started during DTCP.**		
	Start Condition	LFI (NOM) in **Nominal Science** Mode		
	End Condition	No change in LFI configuration		
	Initial Configuration	Cryo biases, 4kHz switching on B/D (**RCA23 switching on A/C**), Polarization A/C=1, B/D=0 (**IF PS TUNING DOES NOT CHANGE THESE DEFAULTS**)		
	End Configuration	Unchanged		
	Execution Type	**MTL** [**Note:** The final parameter setting in step **10bis** will be done with real-time commanding]		
	Duration	**26.25 hours (pretuning) 33x4 hours (tuning)**		
Step	**Reference**	**Proc. Ref.**	**Proc. Title**	**Procedure Inputs**
	ACA Hyper Matrix Pre-Tuning (UM section 13.1.2.7.1)			
10.1	**RCA 18, 19, 22**			
10.1.1	**Perform Pre-Matrix Tuning for VG1 & VG2 (RCA 18,19,22)**	**Pre_Tuning_181922**	**(Special Command Sequence product)**	**pHYM.xls Cryo / Zero Bias References**
10.2	**RCA 20, 21, 23**			
10.2.1	**Perform Pre-Matrix Tuning for VG1 & VG2 (RCA 20,21,23)**	**Pre_Tuning_202123**	**(Special Command Sequence product)**	**pHYM.xls Cryo / Zero Bias References**
10.3	**RCA 24, 26, 28**			
10.3.1	**Perform Pre-Matrix Tuning for VG1 & VG2 (RCA 24,26,28)**	**Pre_Tuning_242628**	**(Special Command Sequence product)**	**pHYM.xls Cryo / Zero Bias References**
10.4	**RCA 25, 27**			
10.4.1	**Perform Pre-Matrix Tuning for VG1 & VG2 (RCA 25,27)**	**Pre_Tuning_2527**	**(Special Command Sequence product)**	**pHYM.xls Cryo / Zero Bias References**

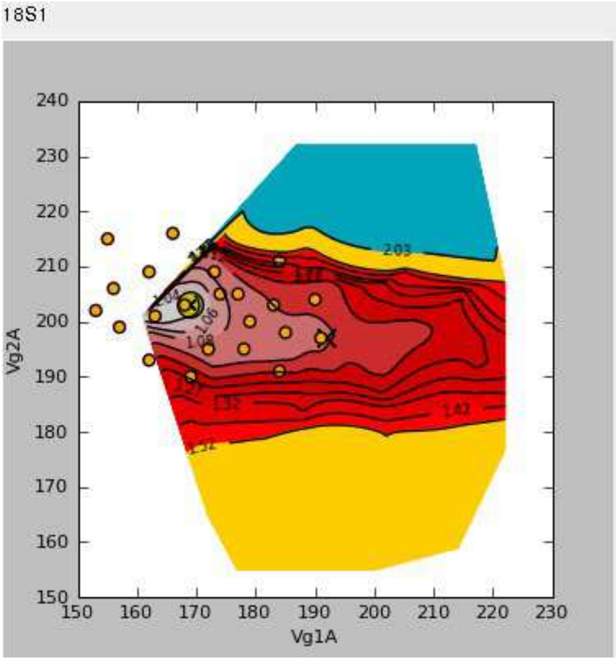
6 Appendix 2 – comparison HYM 1 Vs PRE TUN results

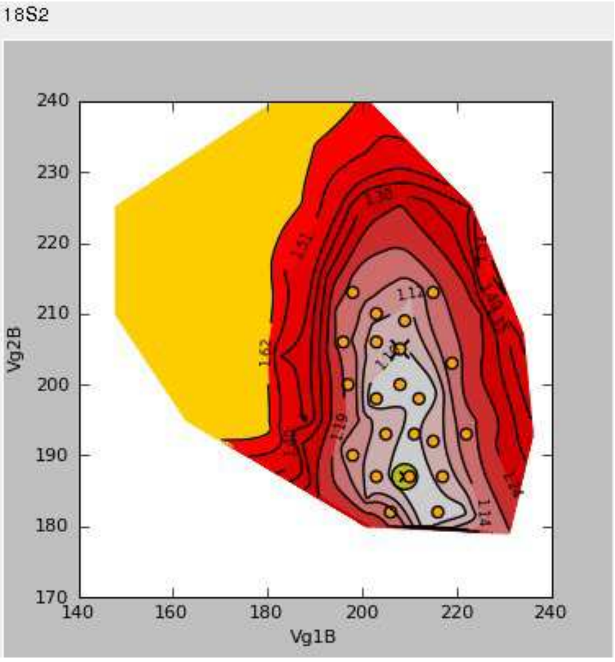
Hereafter are displayed, for each radiometer, the Noise Temperature maps (two dimensional cuts) coming from Pre Tuning and from HYM Tuning 1st step . It is evident that the original shape is conserved in the zoomed bias region where the HYM Tuning is run.

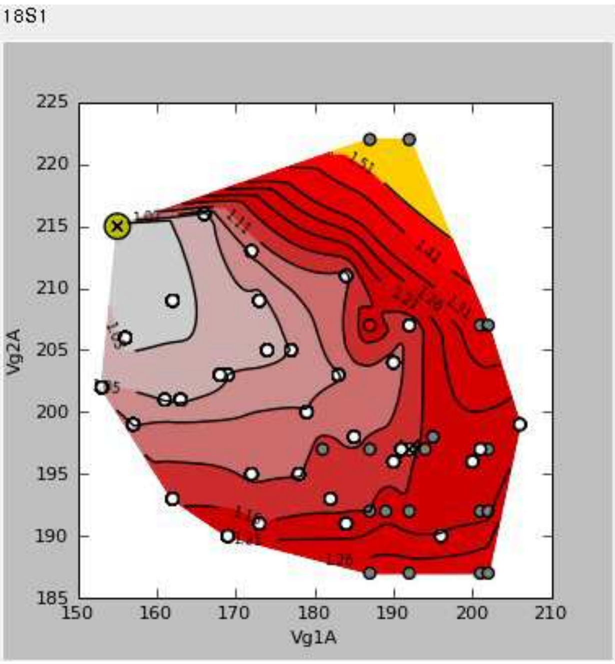
6.1 RCA 18 M

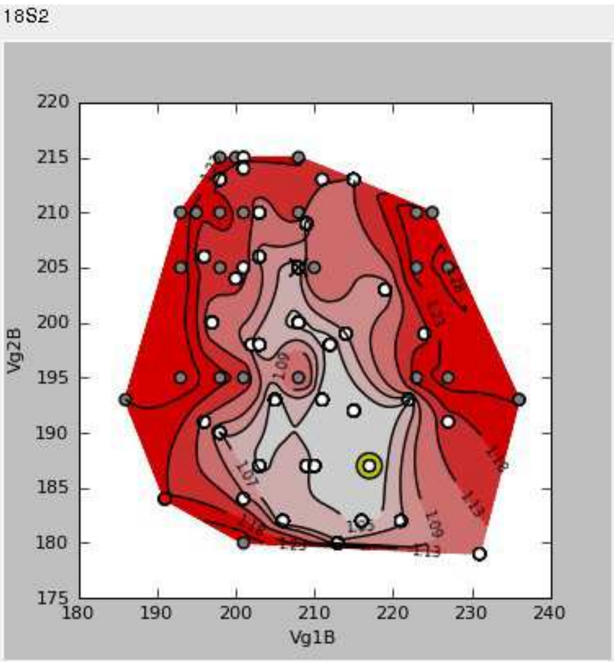


6.2 RCA 18S

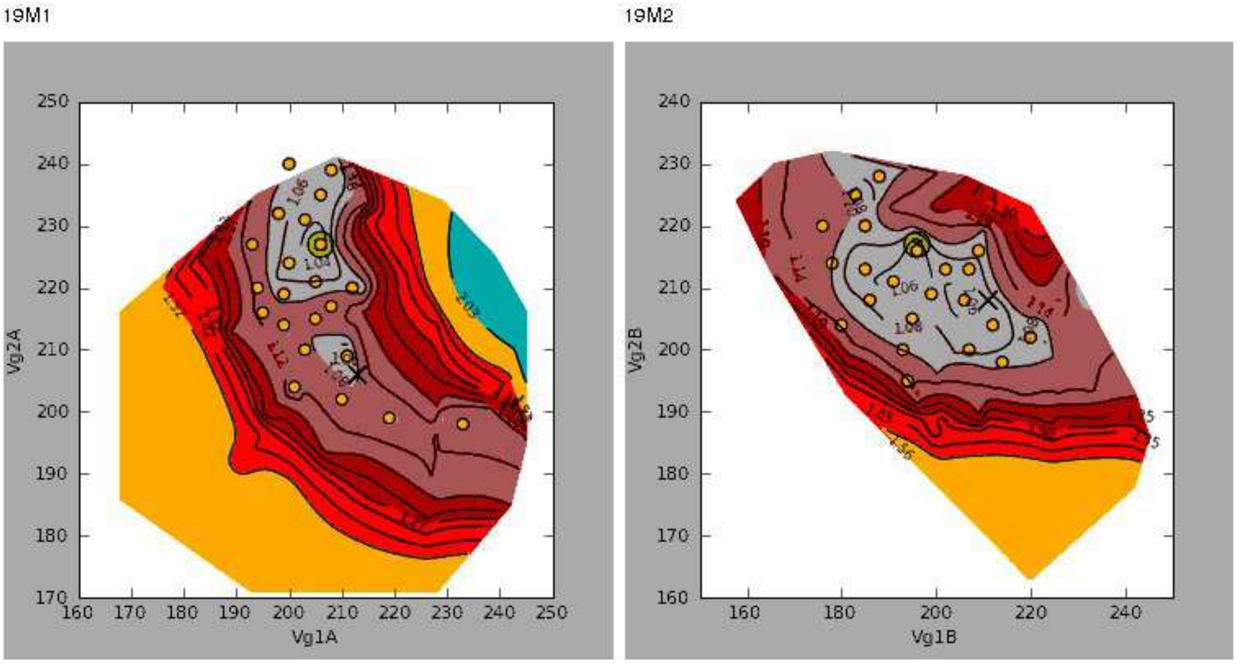


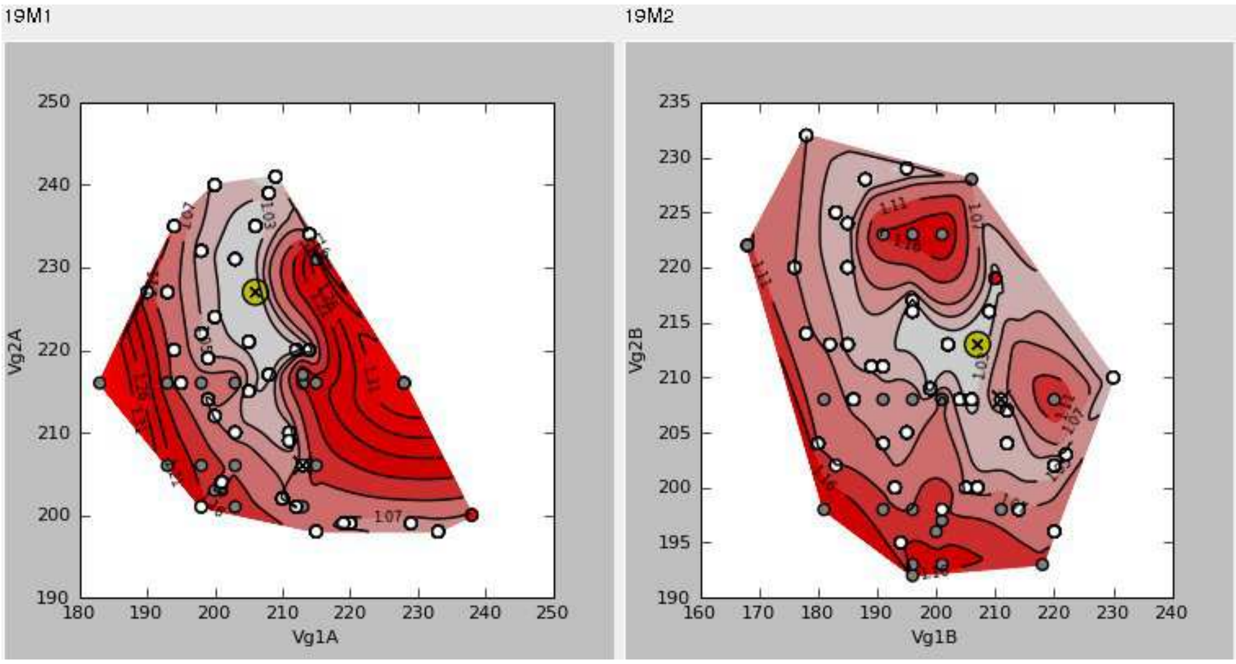




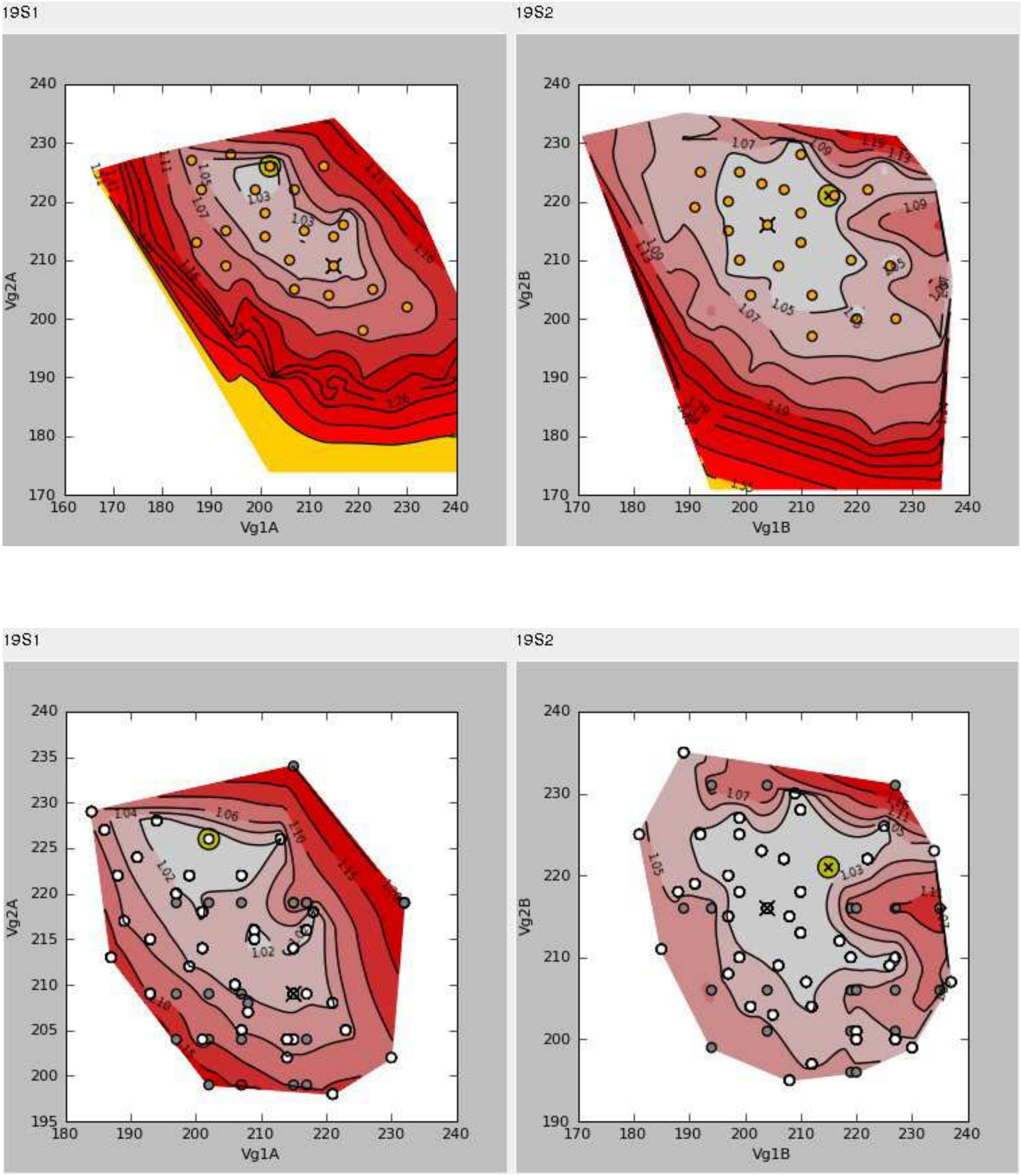


6.3 RCA 19 M

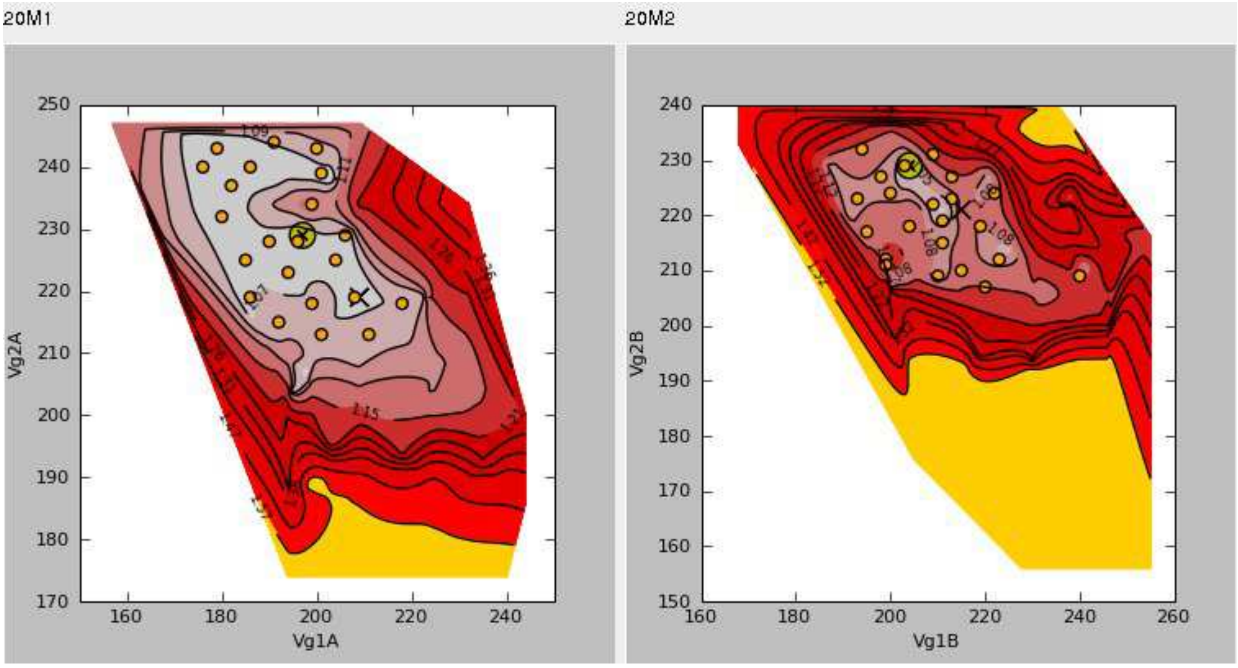


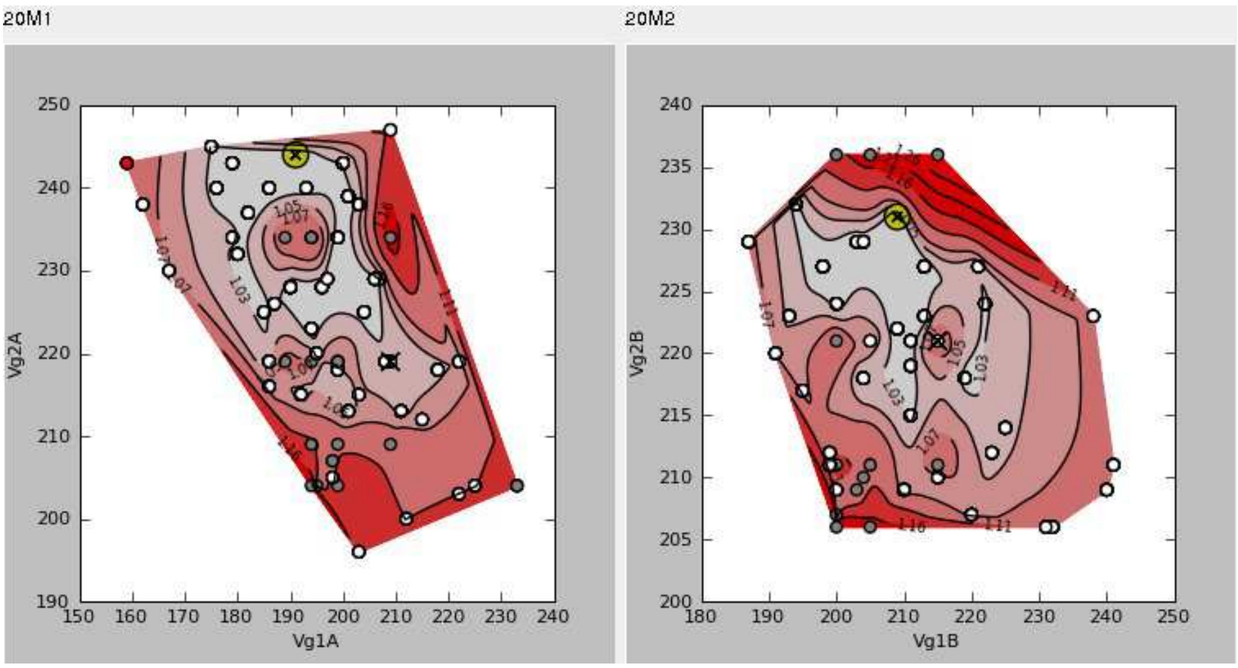


6.4 RCA 19 S

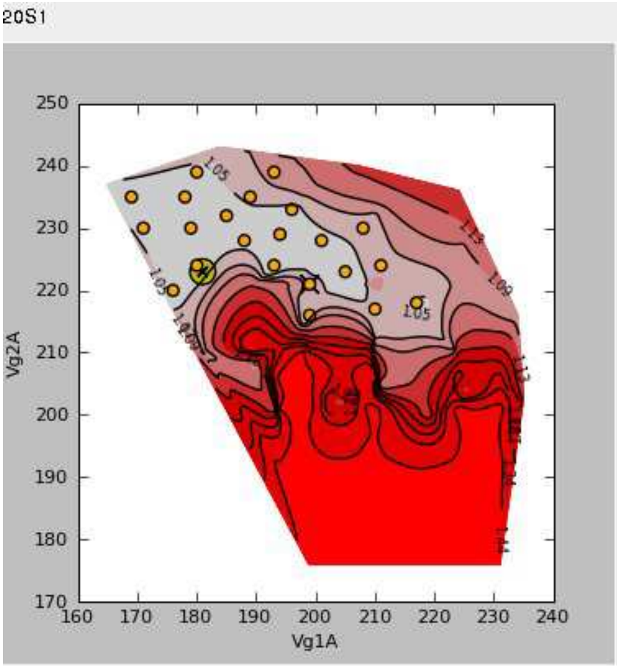


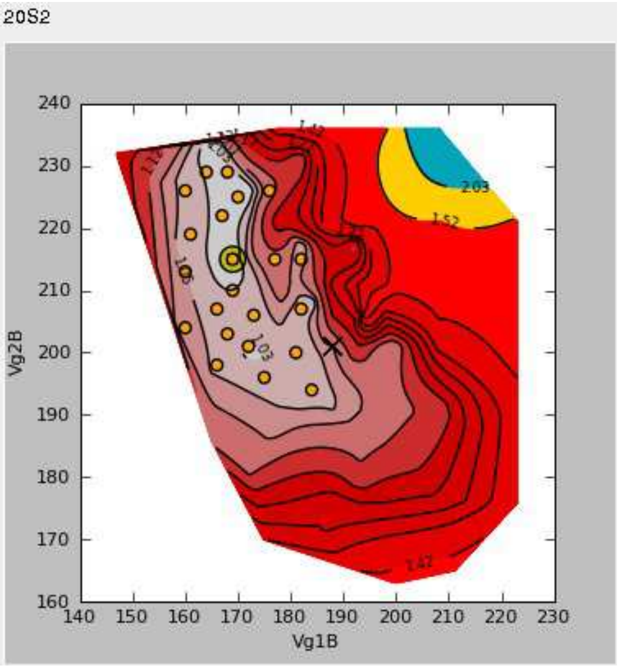
6.5 RCA 20 M

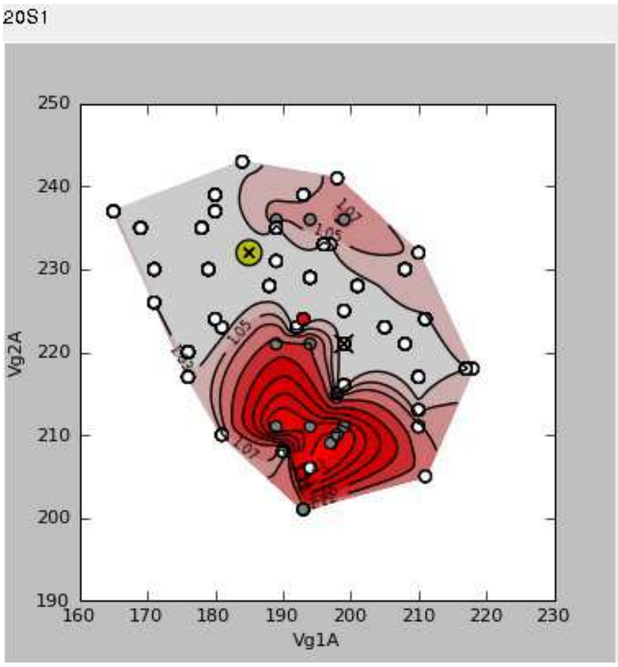


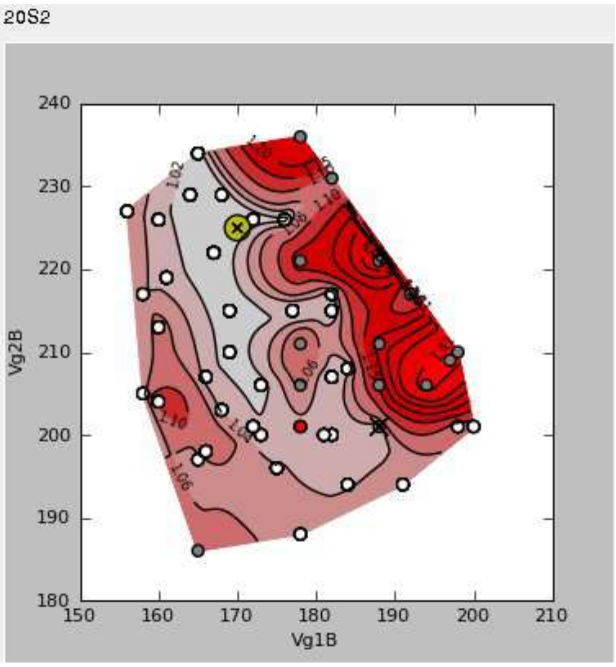


6.6 RCA 20 S

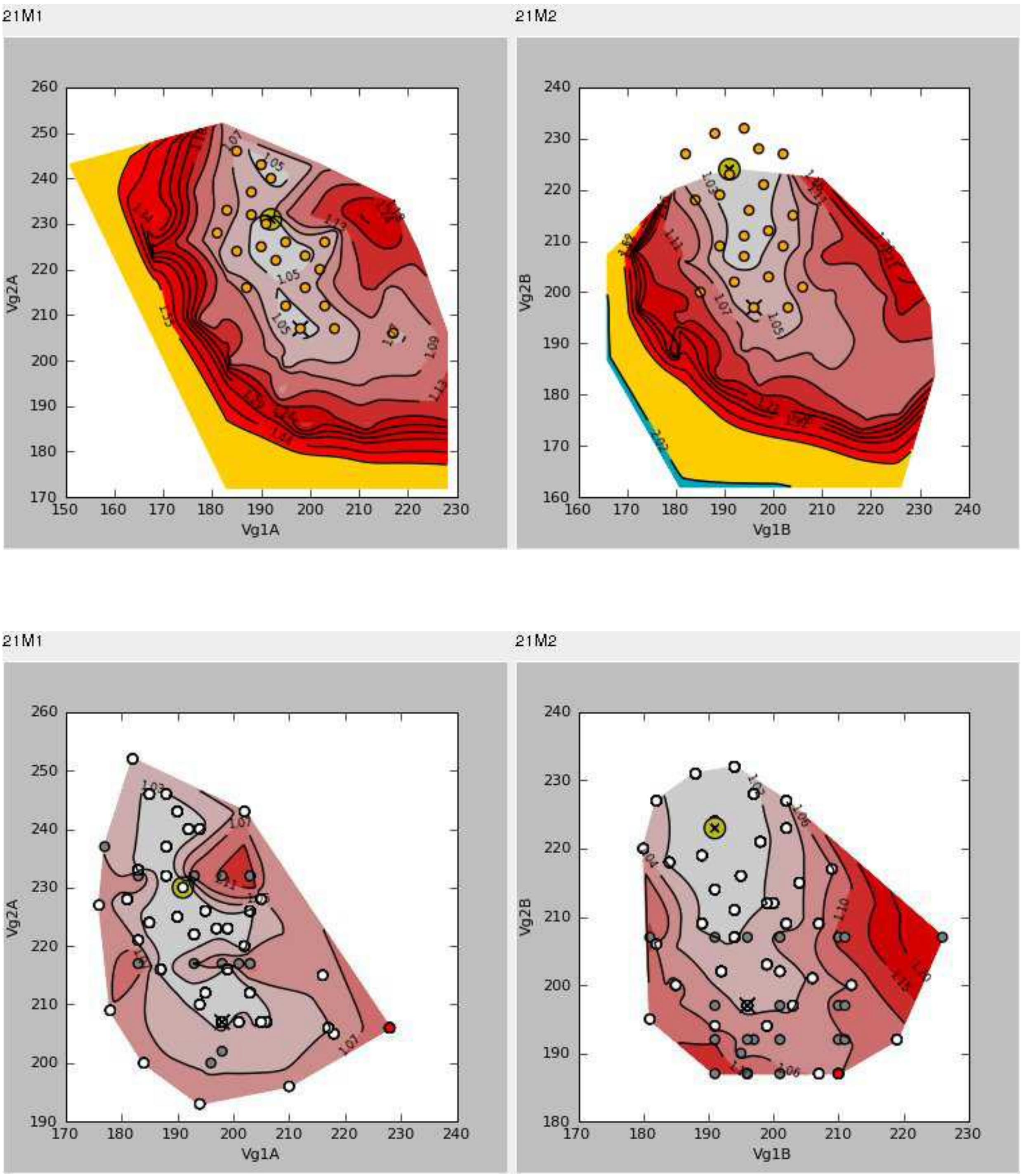




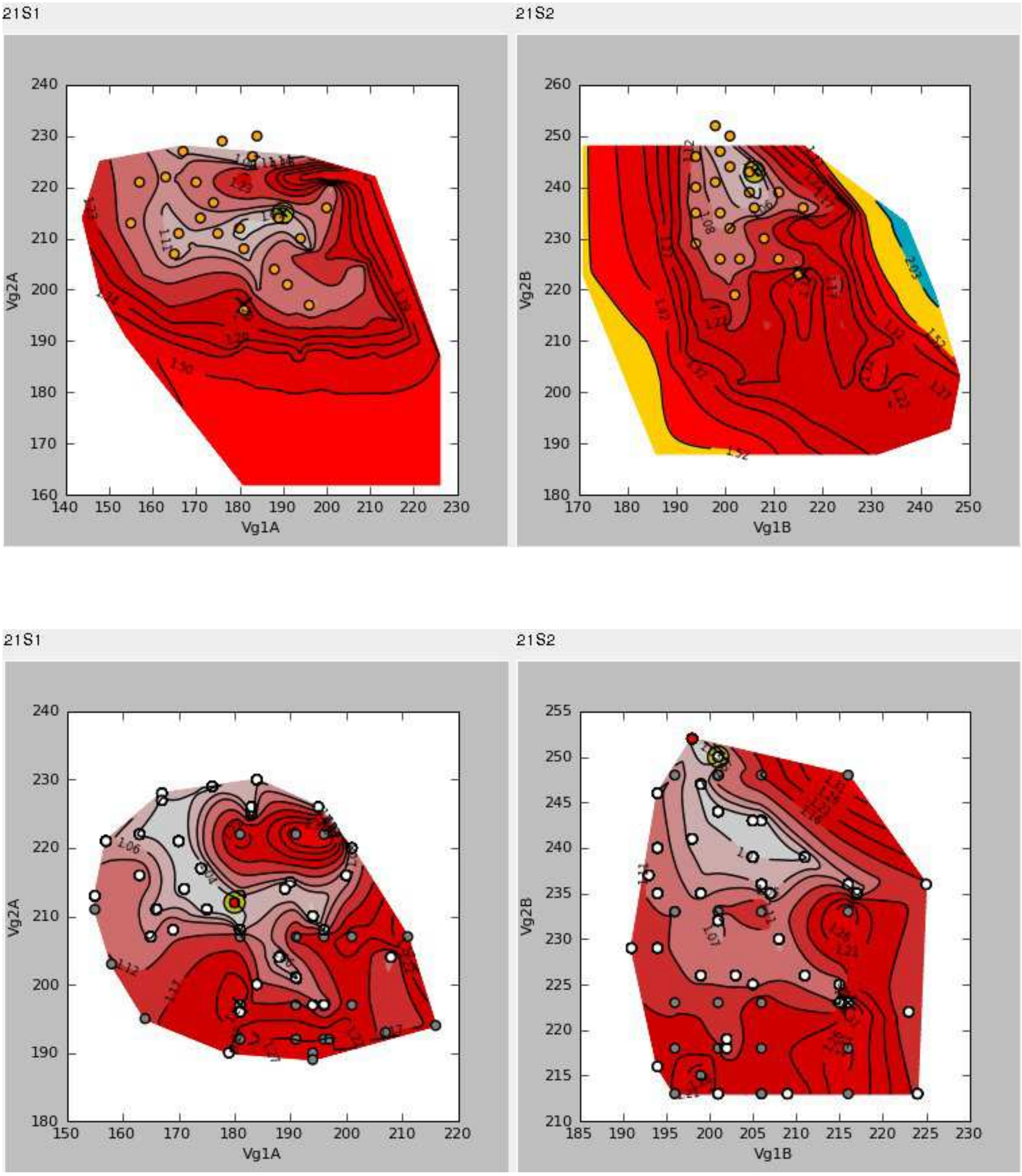




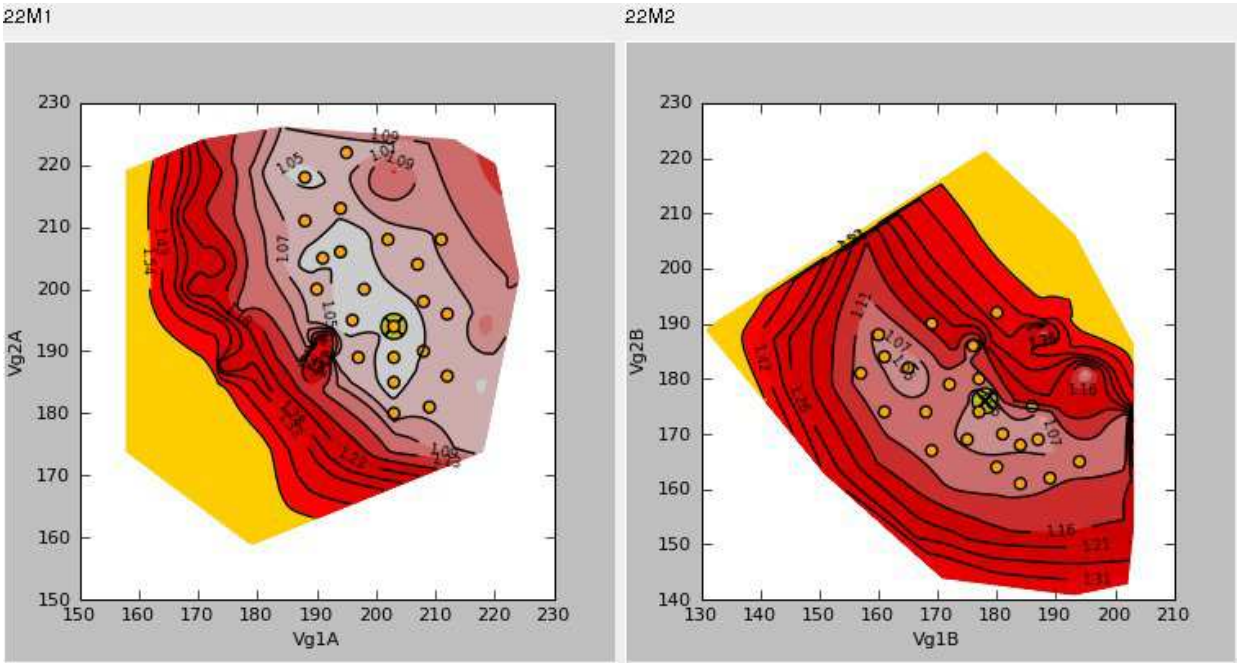
6.7 RCA 21 M

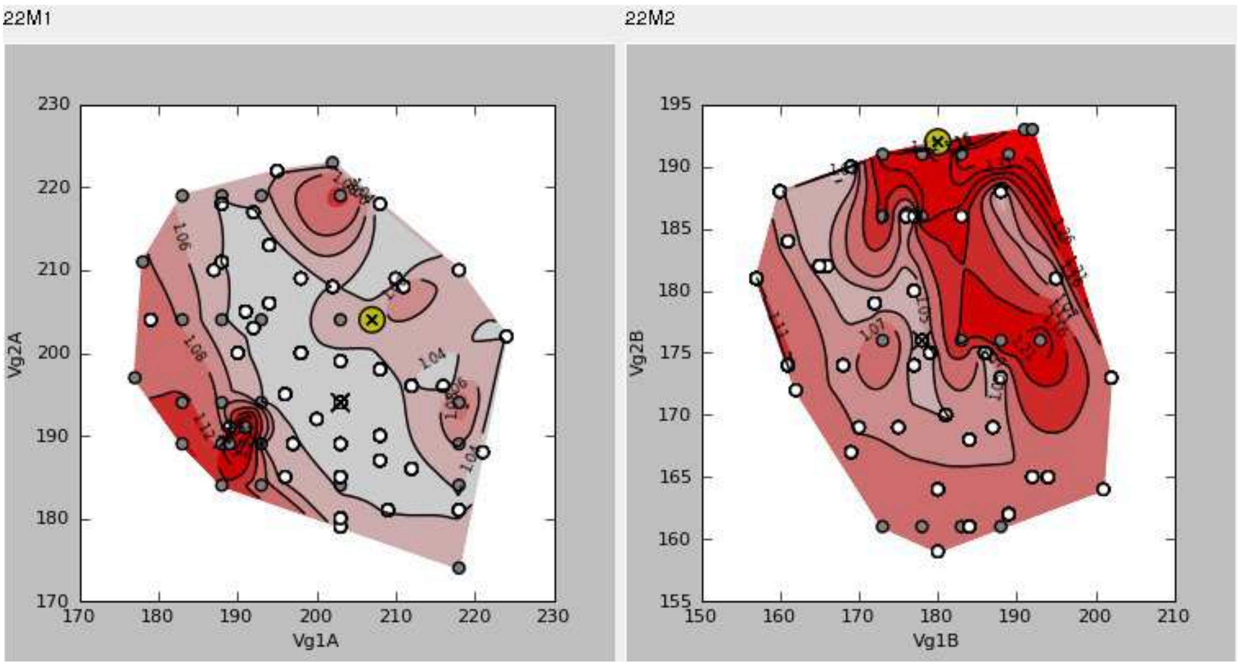


6.8 RCA 21 S

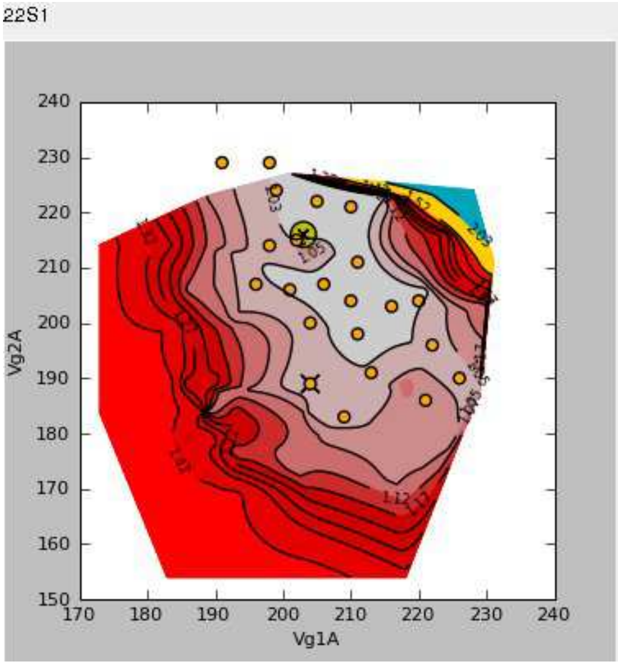


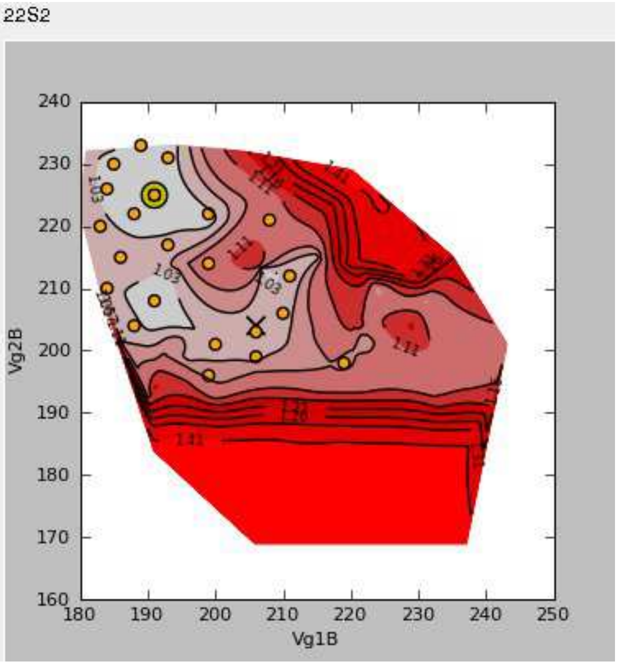
6.9 RCA 21 M

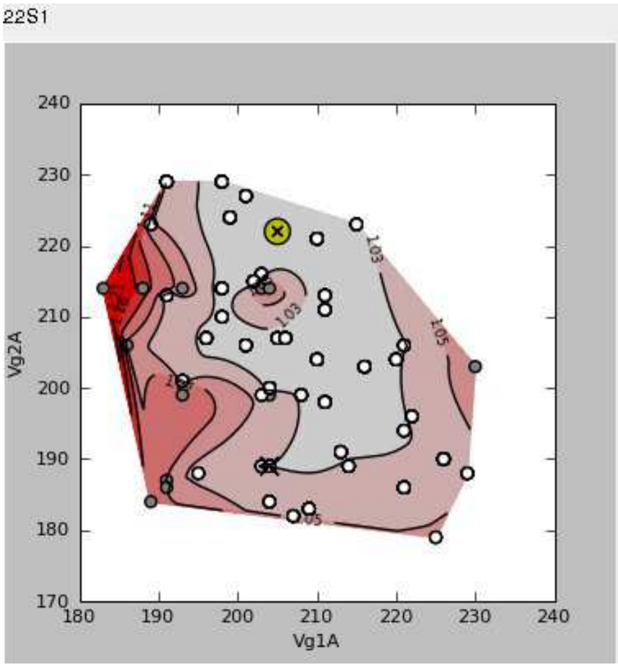


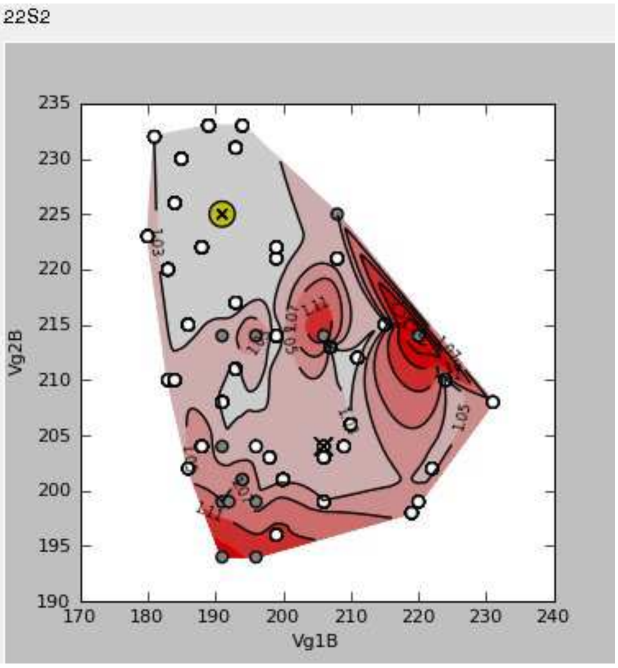


6.10 RCA 22 S

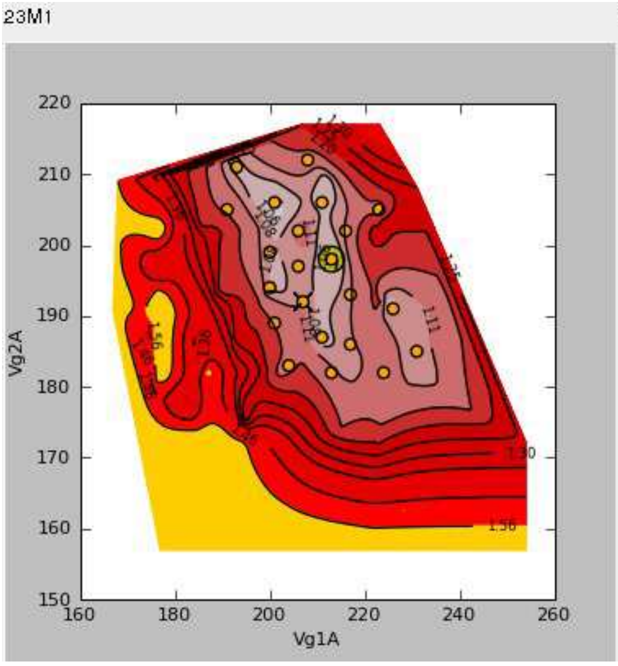


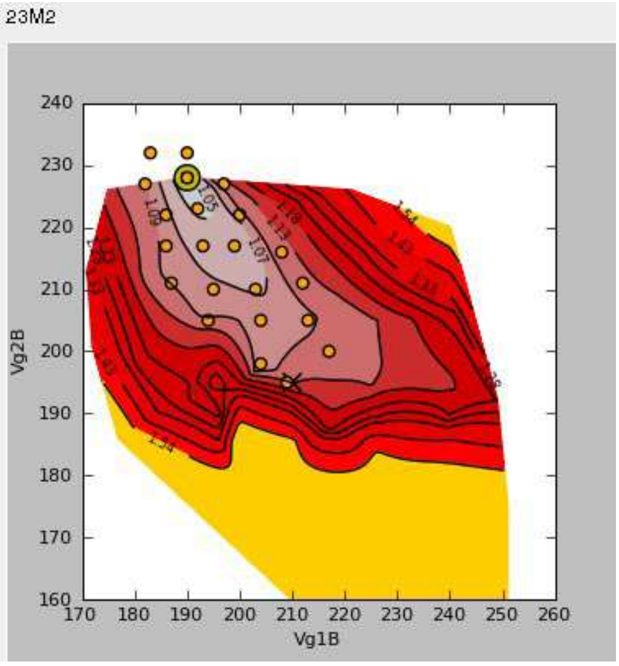


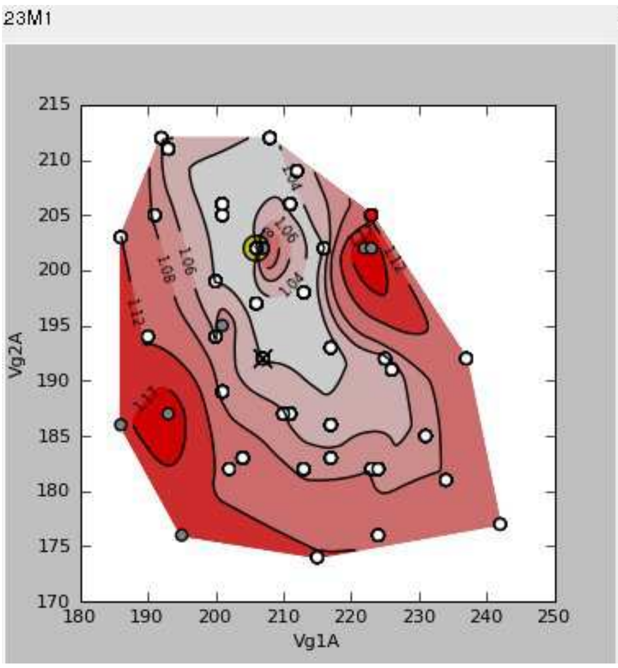


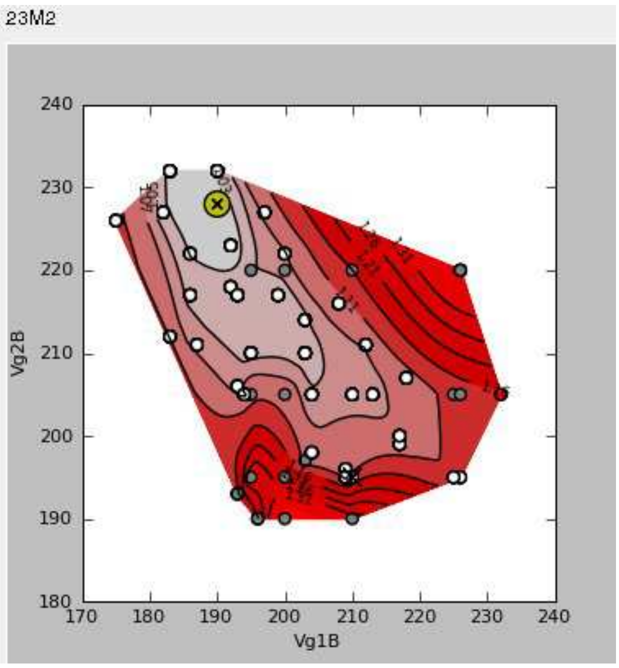


6.11 RCA 23 M

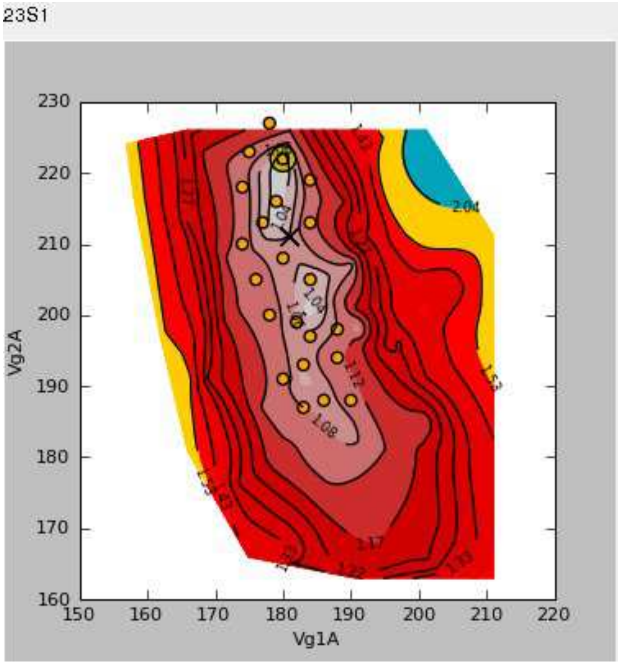








6.12 RCA 23 S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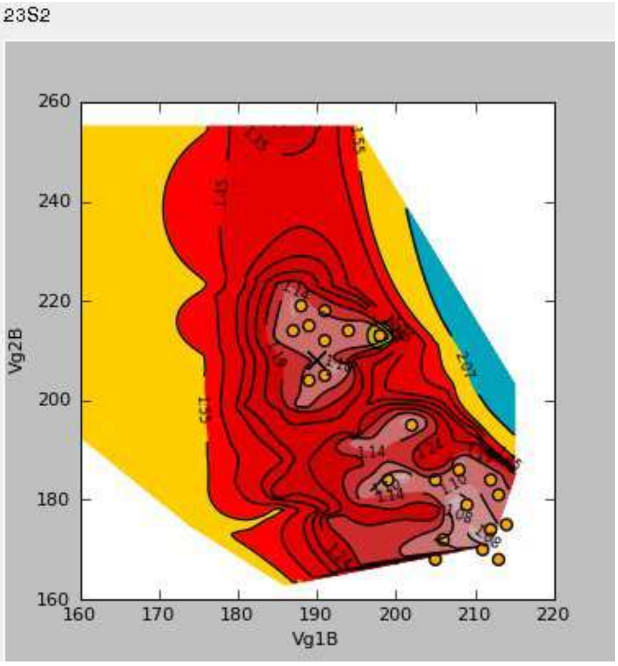
230
220
210
200
190
180
170
160
150 160 170 180 190 200 210 220
Vg1A
Vg2A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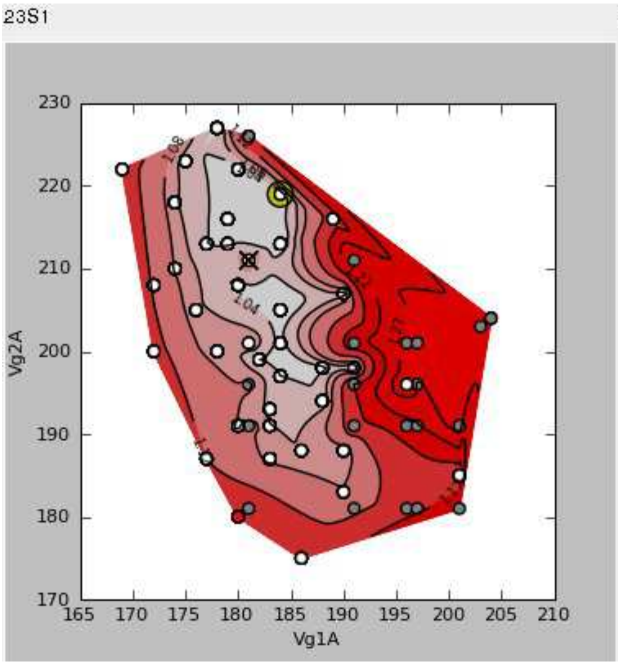
240
220
200
180
160
160 170 180 190 200 210 220
Vg1B
Vg2B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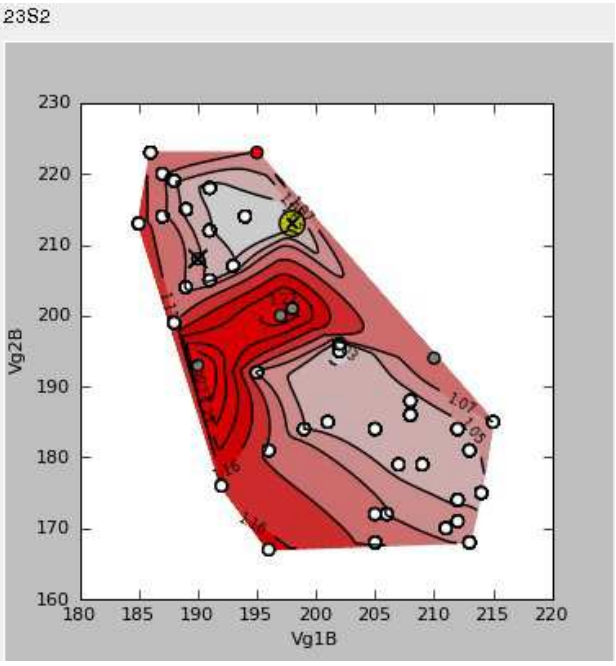
220
210
200
190
180
170
165 170 175 180 185 190 195 200 205 210
Vg1A
Vg2A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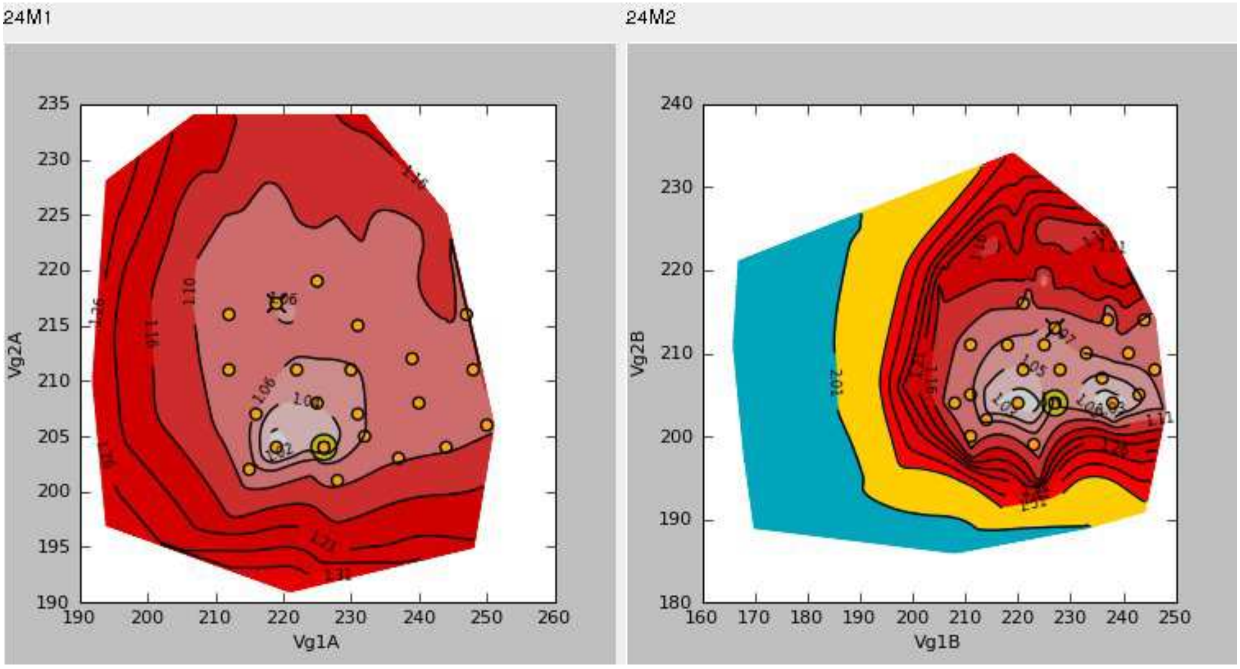
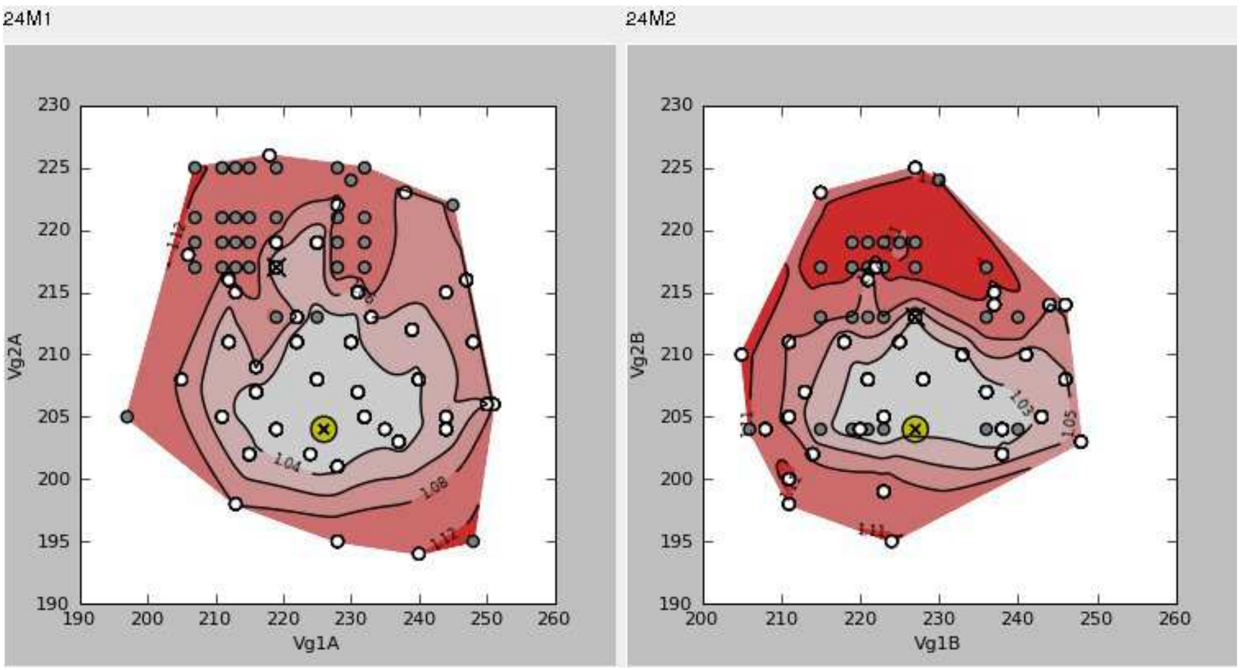
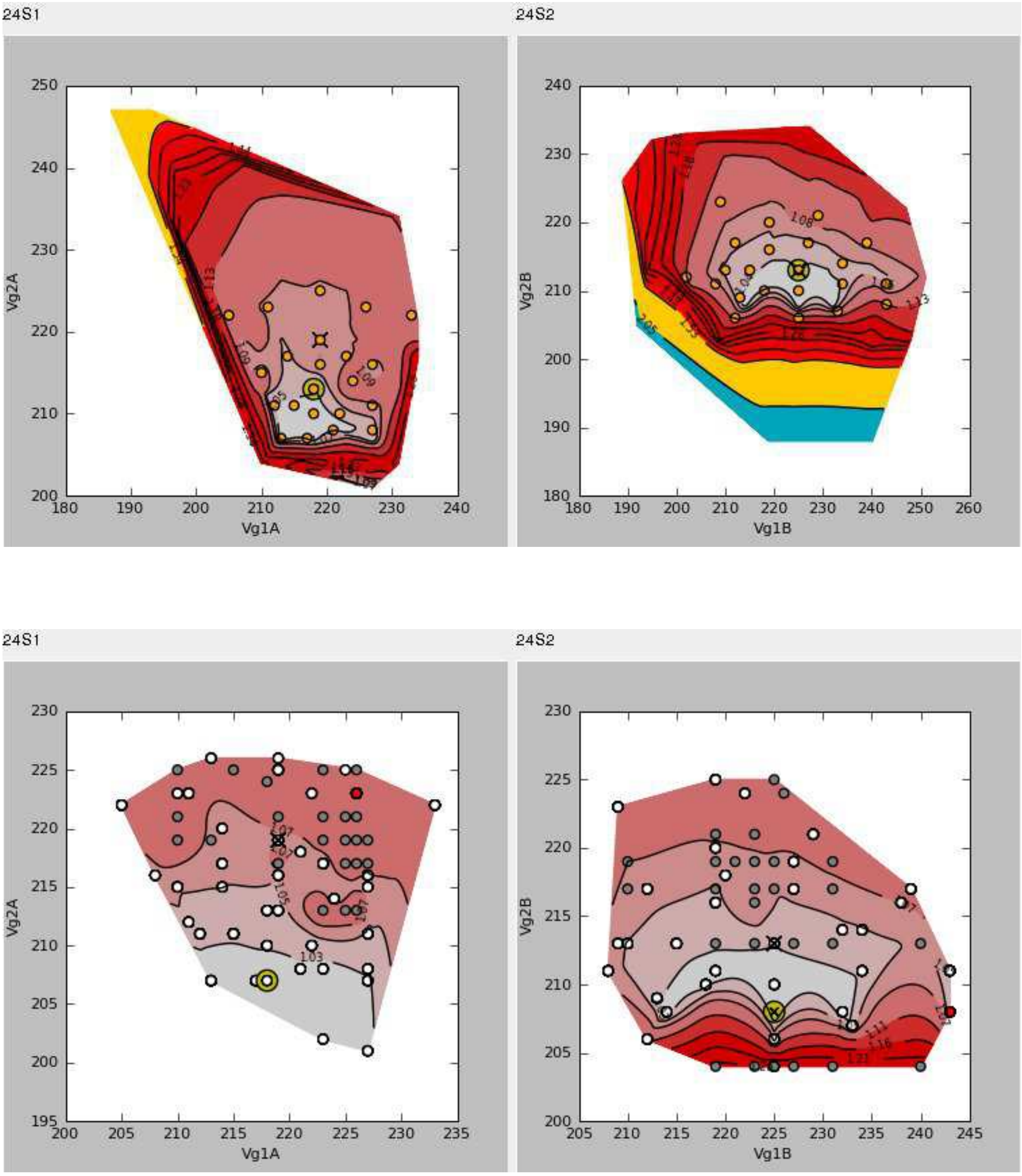
220
210
200
190
180
170
160
180 185 190 195 200 205 210 215 220
Vg1B
Vg2B

6.13 RCA 24 M

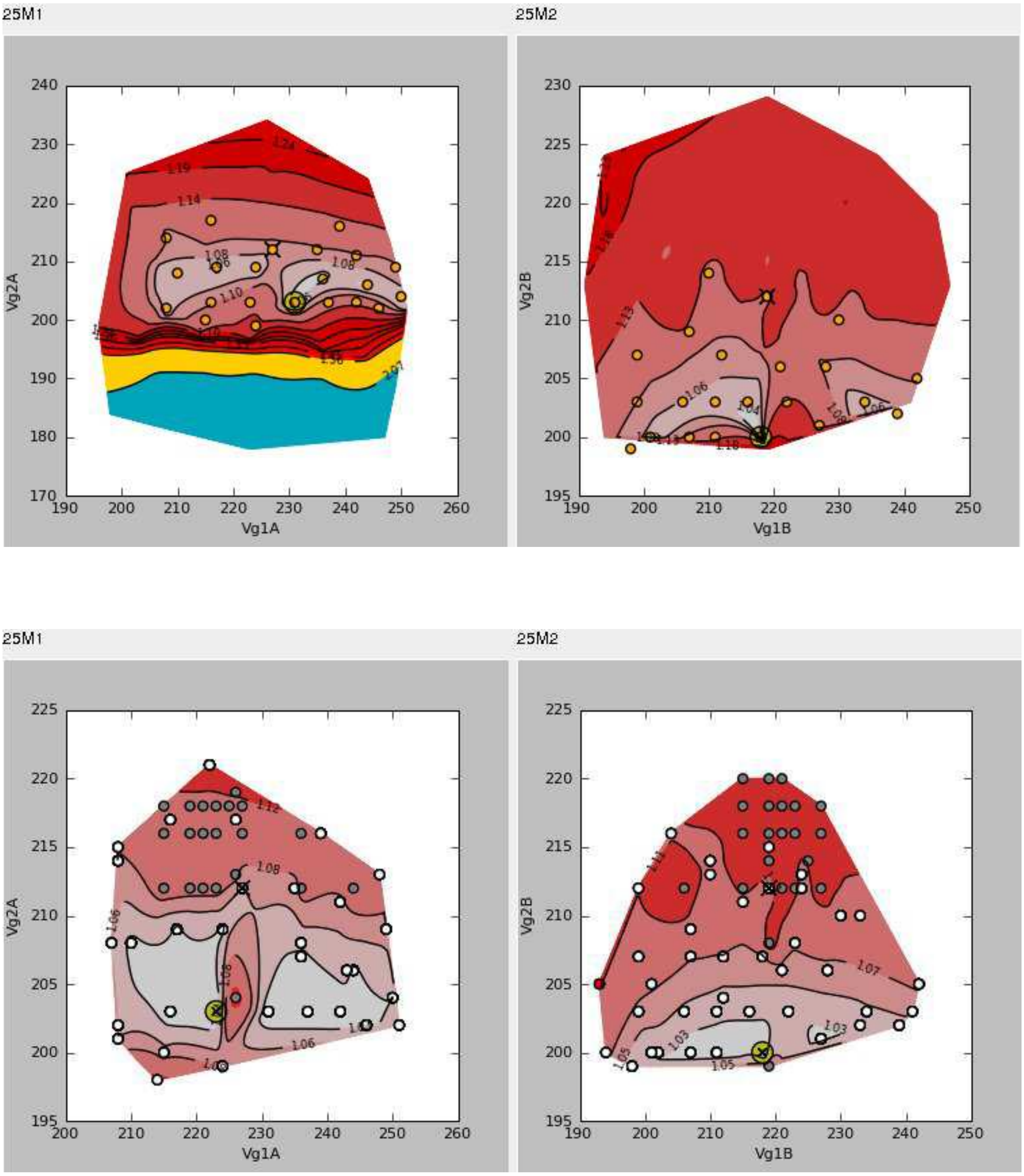




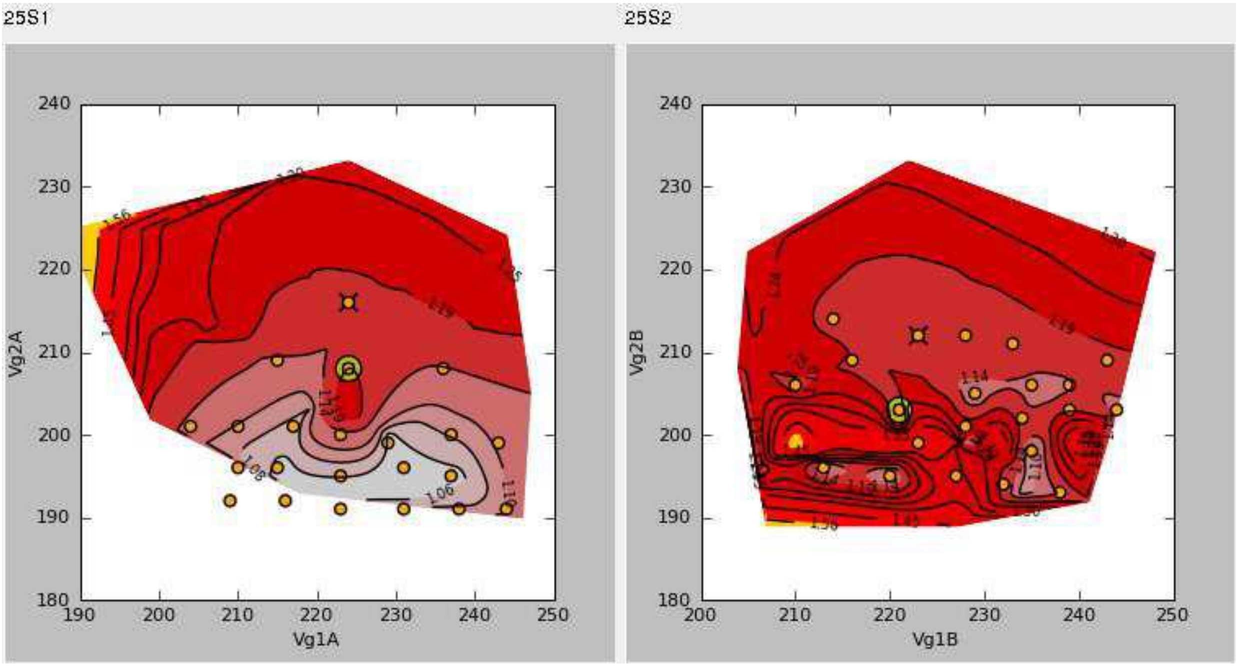
6.14 RCA 24 S

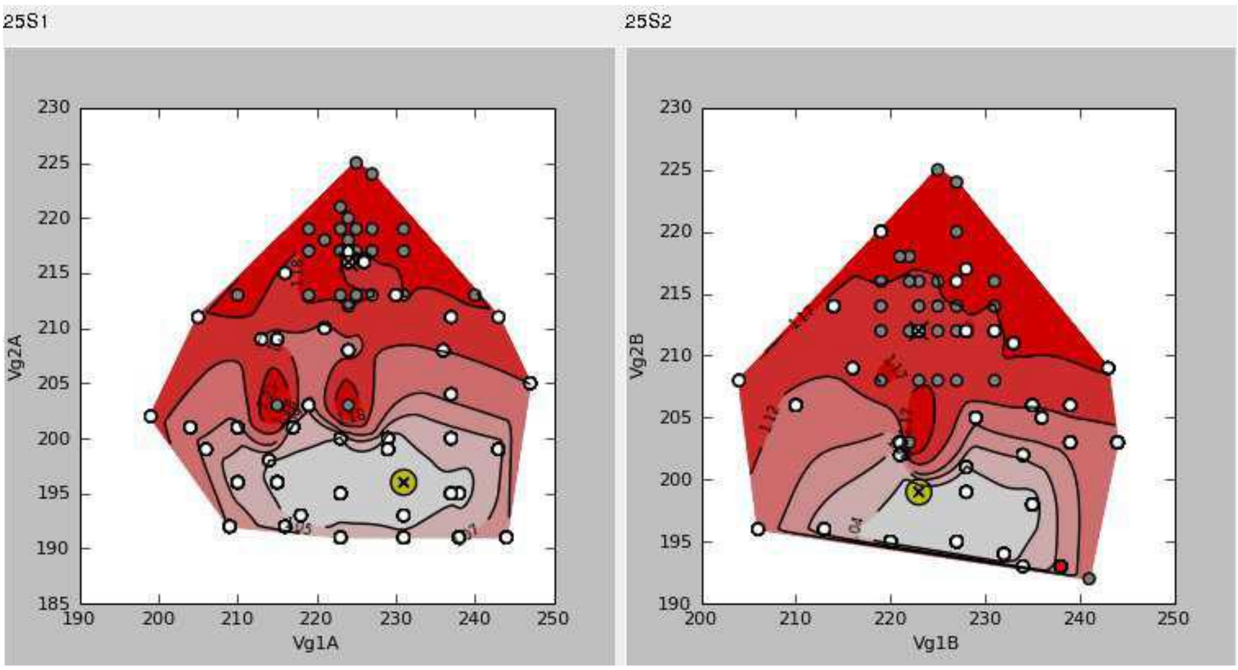


6.15 RCA 25 M

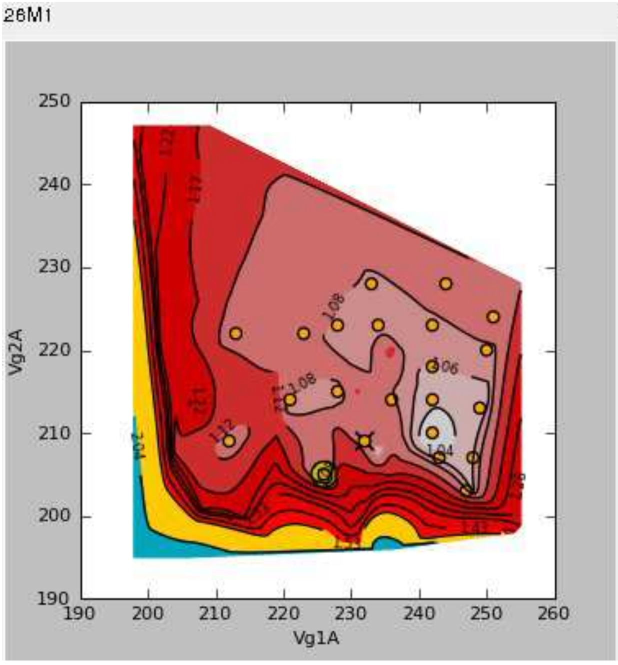


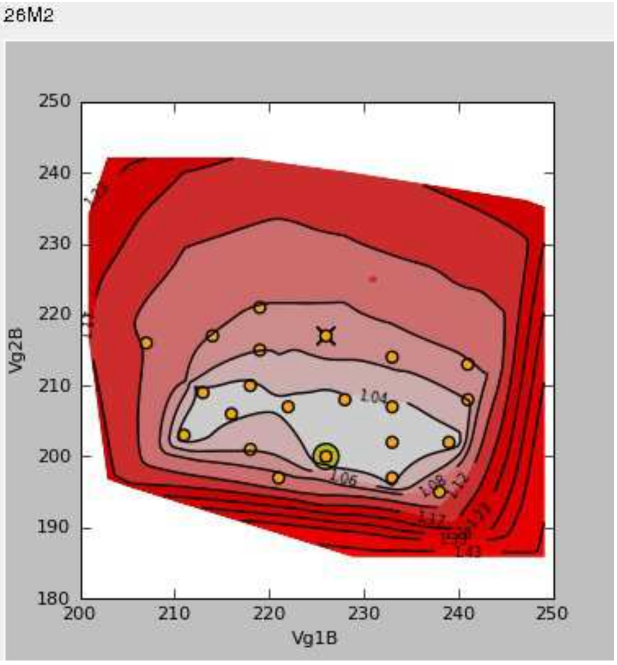
6.16 RCA 25 S

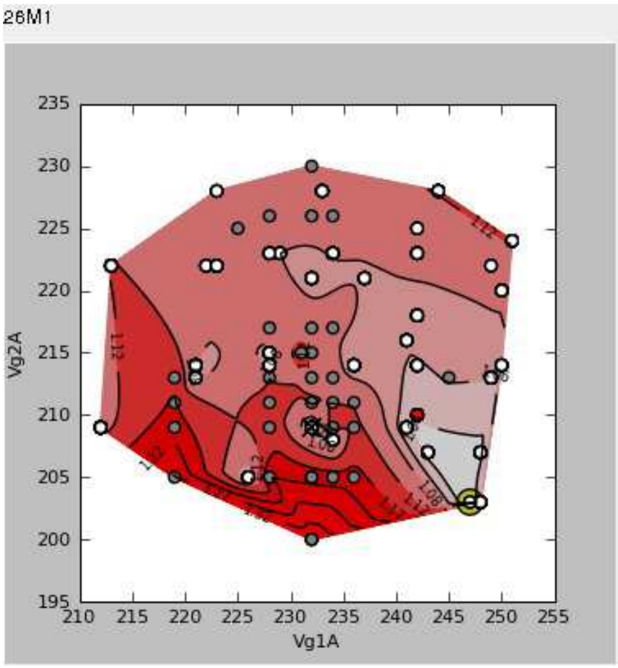


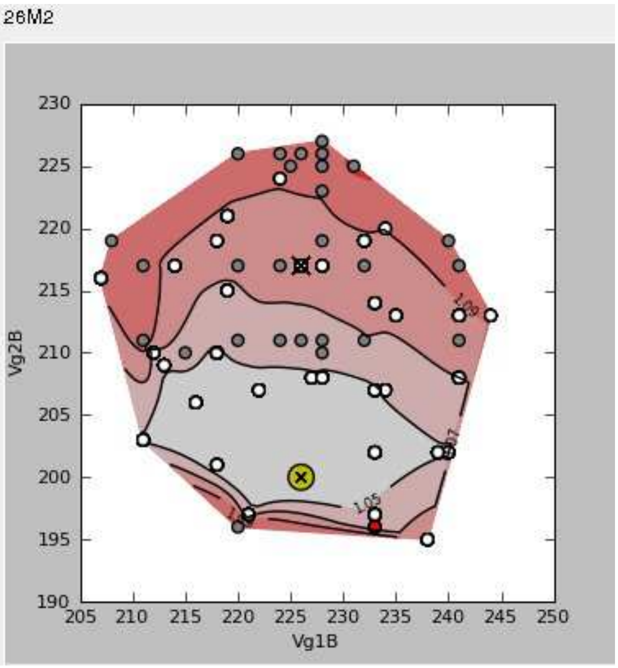


6.17 RCA 26 M

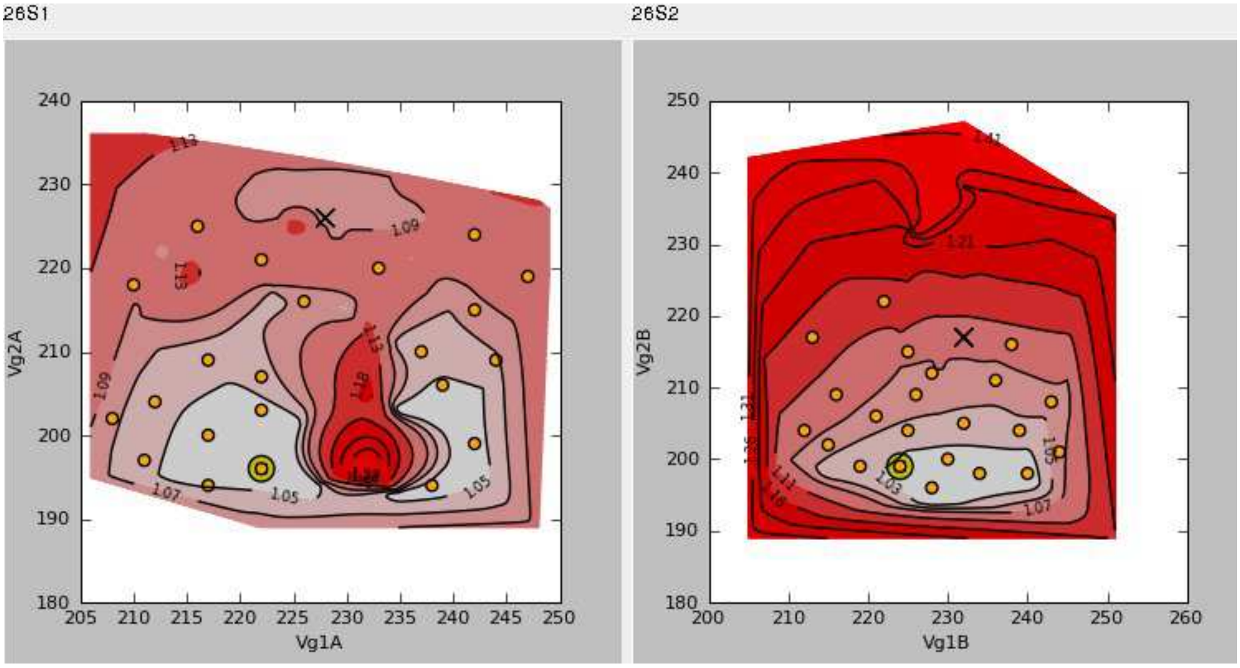


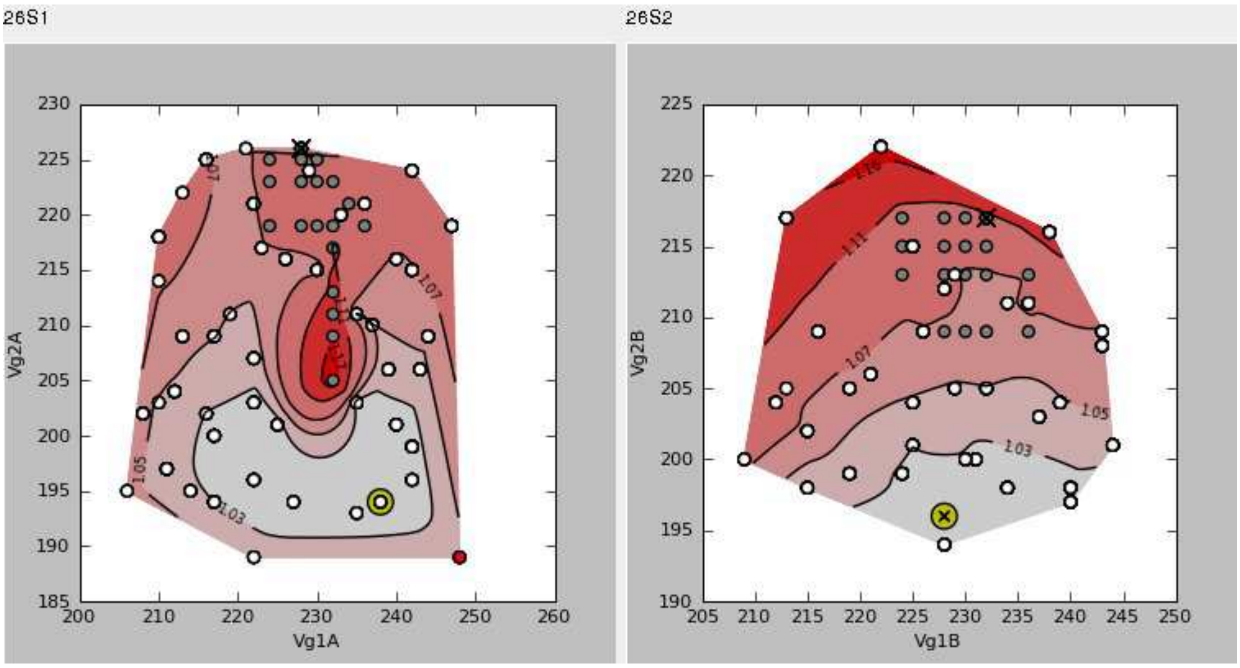




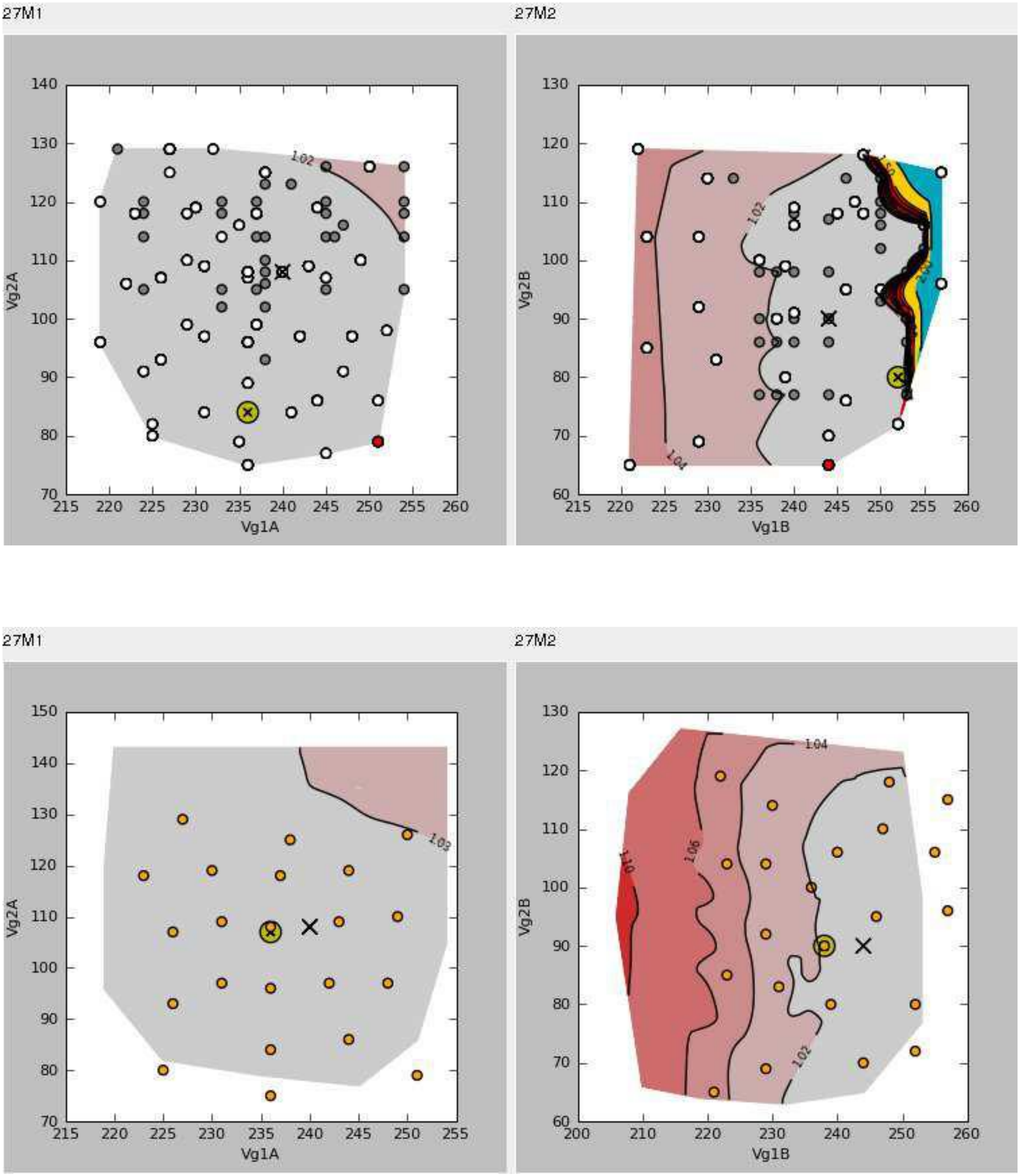


6.18 RCA 26 S

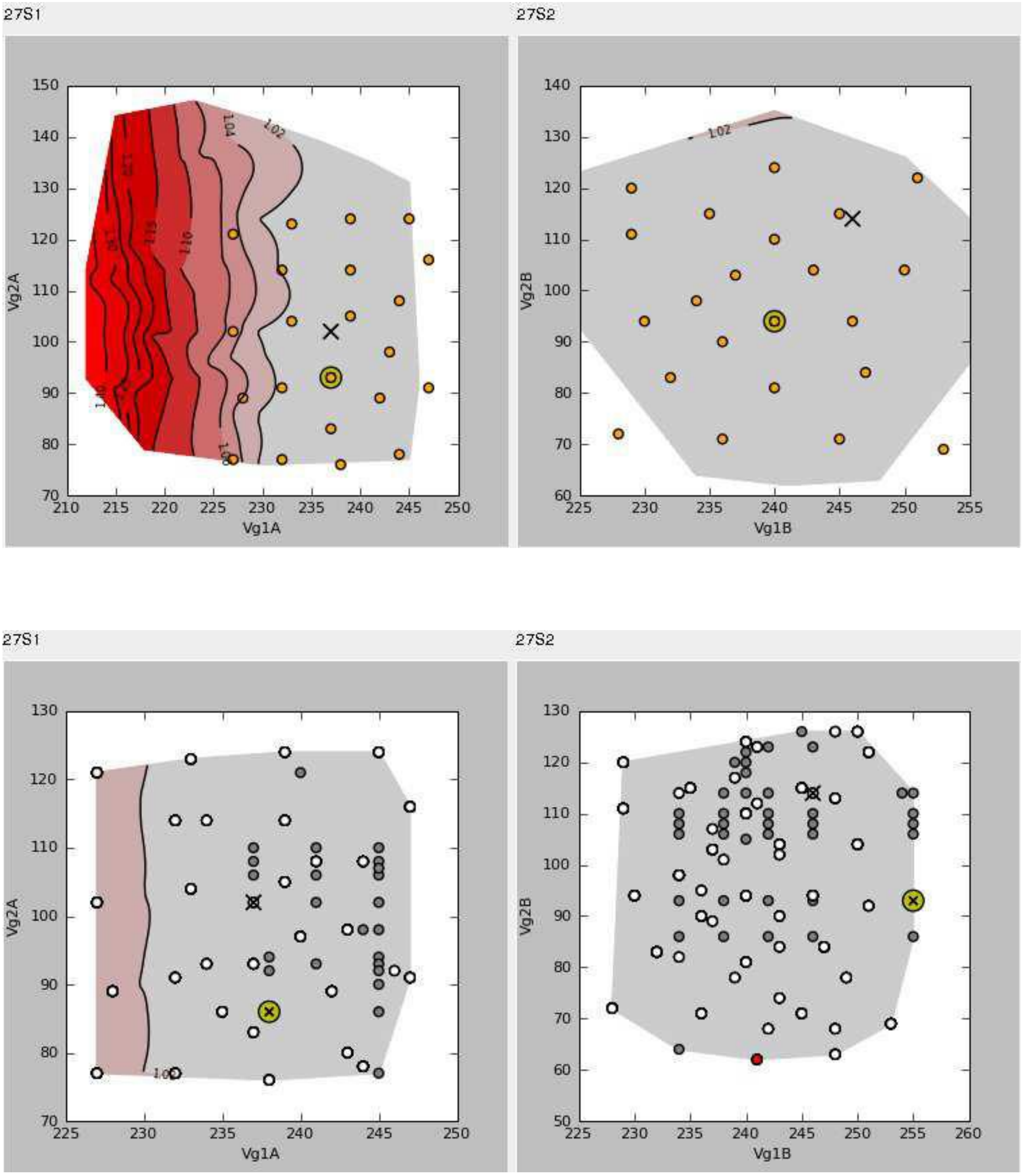




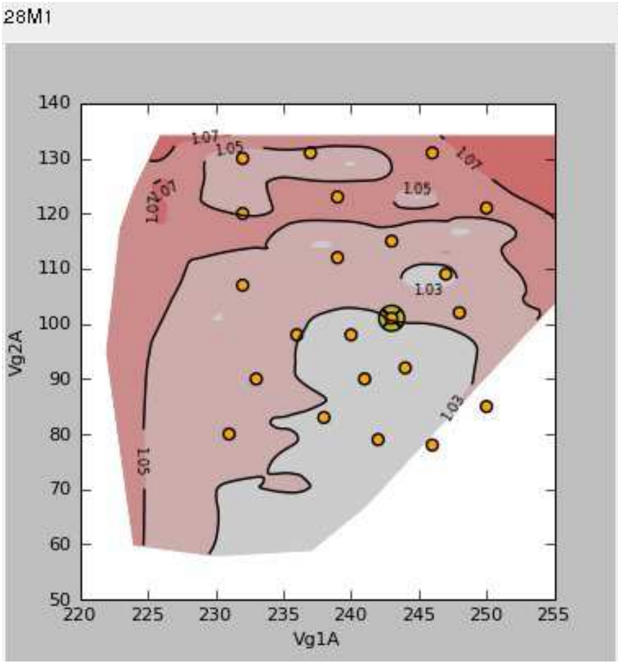
6.19 RCA 27 M



6.20 RCA 27 S



6.21 RCA 28 M


28M1
Vg2A
Vg1A
140
130
120
110
100
90
80
70
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220
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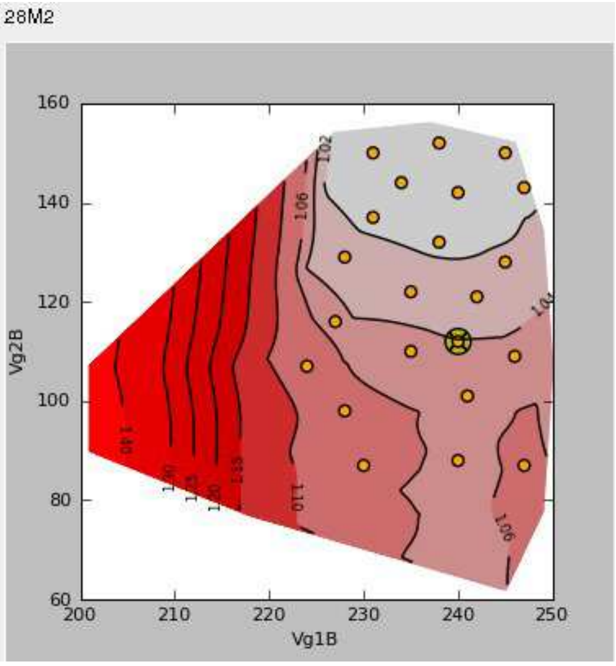
1.07
1.05
1.03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Vg2B
Vg1B
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140
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100
80
60
200
210
220
230
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250
1.02
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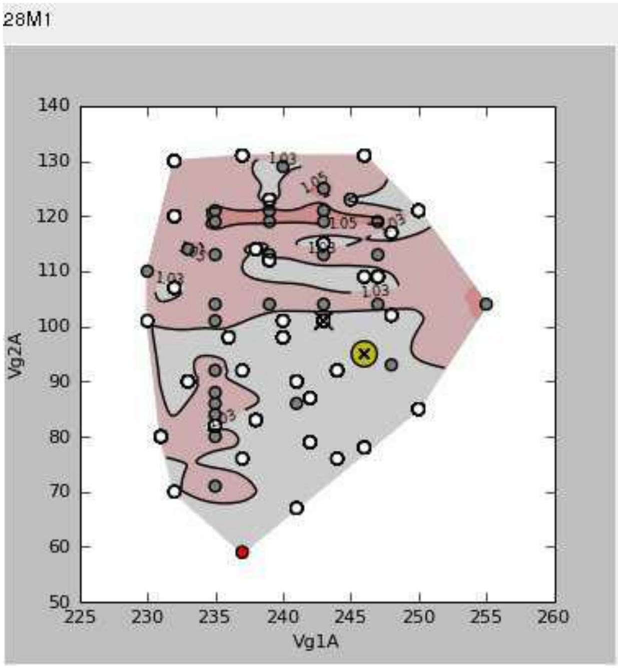
1.06
1.10
1.40


28M1
Vg2A
Vg1A
140
130
120
110
100
90
80
70
60
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225
230
235
240
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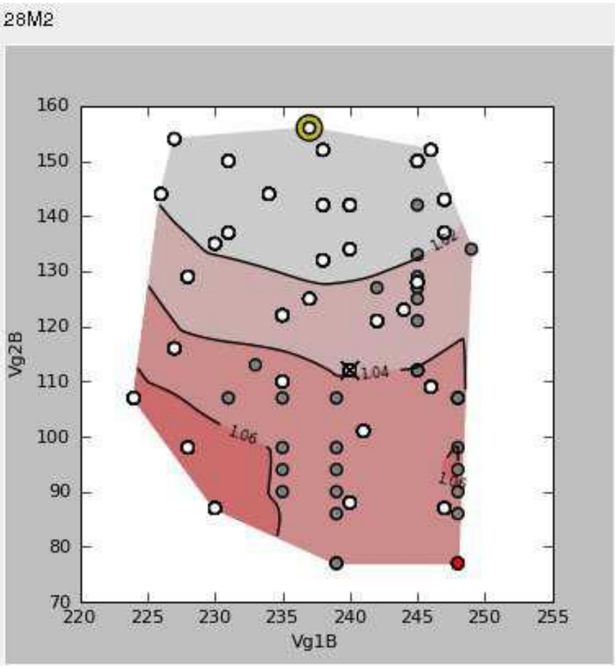
1.03
1.05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Vg2B
Vg1B
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150
140
130
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100
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240
245
250
255
1.02
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6.22 RCA 28 S