TITLE: # CSL ACA Matrix Tuning Report

DOC. TYPE: Test Report

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CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
1.0	August	All	First Issue of the Document	LFI TB/TV test report

TABLE OF CONTENTS

1 ACRONYMS

ACA	Amplifiers Chain Assembly
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
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
LNA	Low Noise Amplifier
OBC	On Board Clock
RAA	Radiometer Array Assembly
REBA	Radiometric Electronic Box Assembly
S/C	Spacecraft
SCOE	Spacecraft Control and Operation 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 INTRODUCTION

This document has been issued in the frame of ASI contract that has been released for the activities of Planck-LFI Phase E2

2.1 Purpose and Scope

This document is a report of the LFI LNAs Tuning Verification performed at Centre Spatiale de Liege during the TV / TB campaign. In particular the test phases are from Ph–5–03 to Ph-5-04-d-1.

2.2 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 3.0.4

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3 APPLICABLE AND REFERENCE DOCUMENTS

3.1 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] TV Tests: LFI Test Under Cryogenic Vacuum, PL-LFI-PST-PR-021 2.2

3.2 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] F. Cuttaia, Technical Note on bias tuning, DRAFT, Jan 2008

[RD4] F. Cuttaia, Tuning strategy for CSL, DRAFT, Apr 2008

[RD5] L. Terenzi, F. Cuttaia, S. Grassi, A critical data analysis of the RCA27 Flight Spare Tuning, PL-LFI-PST-TN.084 0.1 DRAFT, April 2008

[RD6] F.Villa et al. CSL phase switch tuning test report. PL-LFI-PST-RP-038

4 INTRODUCTION

The tuning of Amplifiers' Chain Assembly (ACAs) is performed by varying the gate voltage biases (V1 and V2) in order to reach the best working condition, i.e. when the noise temperature of the radiometer, measured between two temperatures of one of the loads, is minimum.
The first point in temperature is taken when the HFI 4K shield, where the LFI reference loads are connected, is at about 22 K, the second point in temperature is taken during the final HFI shield thermalization at about 4.5 K.
During each of the two stages, a matrix of 49 values of Vg1 and Vg2 values are supplied sequentially to each amplifier with about 30 sec interval between each other.
The method followed to choose the 49 values assigned to the different RCAs are discussed in [RD3] and [RD4].
In order to minimize electrical crosstalk, at each temperature point two RCAs, belonging to different power groups and BEM trays, are tested at a time.

At the end of the two temperature steps, for each of the bias couples the noise temperature is evaluated by the Y-factor method:
$T_n = \frac{T_{ant}^{high} - Y \cdot T_{ant}^{low}}{Y-1}$ where: $Y = \frac{V_{load}^{high}}{V_{load}^{low}}$ and voltages and antenna temperatures refer to the load whose temperature is varying, which in the case of the CSL test is the reference load. A third control run of the matrix tuning is performed when the reference load temperature is at about 15 K. Due to schedule opportunity also a fourth stage was performed with the reference load at about 18.5 K.
The results shown in this analysis are obtained from the first and the fourth datasets which were the most stable. Step at 18.5 and at 15 were exploited to obtain results for, respectively, the RCA28 S1 - S2, whose switch currents were not optimized during first step, and RCA24 S1, whose bias table applied during the test was updated in order ot avoid saturation.

5 TEST RECORD AND TEST DATA

Here the test record as reported in LFIwiki at
http://belzebu.lambrate.inaf.it/twiki/bin/view/LFI/CSLTestRecord
In summary the ACA tuning first phase was started on July 7th at 10:20 and nominally ended on 20th July at 16:27. In this period the procedure script failed on TUN_0050. Some saturations of RCA 28 were observed in TUN_0054, TUN_0055. During TUN_0067 the correct startup procedure was not applied correctly (only one of the two chains under test were switched off). TUN 0060 was performed with RCA28 S1 and S2 switch currents not optimized. RCA24 S1 tables were optimized since TUN_0078 so that saturations occurred only at the beginning of the procedure and were soon recovered. During TUN_0082 a sudden switch off of the SCOS machine caused the test failure.

Time	Test ID	End Time	Test Log
2008/07/07 10:20	TUN_0054	16:27	The RCA28 is saturating on all channels. The drain currents are M1=18.6, M2 = 18.6, S1=10.2, S2=11.3. No ACA tuning has been done within this test.
2008/07/07 17:39	TUN_0055	19:53	ACA step 1 tuning RCA18 and RCA21. At 18:59 the RCA28 was switched on without the soft procedure and therefore all the channels saturated. The ACA tuning must be restarted again.
2008/07/07 19:56	TUN_0056	22:47	False start in the ACA step 1 tuning procedure. At 20:50 we discovered that the ID of RCA24 S1 is 15 mA - 5mA greater than the values measured during CRYO1. At 22:13 we discovered that the operator was changing two channels at the same time. The test must restart.
2008/07/07 22:50	TUN_0057	02:46	ACA step 1 tuning at 22K on reference load. RCA18 and RCA21. At the beginning of the test RCA18 was not initialised properly. At 00:02 we realised that the bias values used on channel S2 were not in the correct order. At 00:42 the tests restarted with the proper setup.
2008/07/08 02:48	TUN_0058	04:52	ACA step 1 tuning. RCA19 and RCA22.
2008/07/08 04:54	TUN_0059	07:06	ACA step 1 tuning. RCA20 and RCA23.
2008/07/08 07:06	TUN_0060	13:41	ACA step 1 tuning. RCA (with approximate times) RCA24 and RCA25 (07:20-09:10) RCA26 and RCA27 (09:30-11:50) RCA28 (11:35-13:40).
2008/07/12 08:43	TUN_0067	10:00	09:16 RCA18, RCA21 ACA step 1b tuning start with 4K reference load at 18.6K. 09:24 test stopped. Check on start-up procedure RCA18 has not been switched off. 09:26 4kHz on. 09:36 RCA18 and RCA21 matrix application start S2. 10:00 closed as the procedure was not applied in the correct way - RCA18 not switched off. ABORTED
2008/07/12 10:02	TUN_0068	12:35	RCA18/RCA21 tuning test. 10:18 RCA18 off. 10:20 RCA21 off. 10:21 RCA18, RCA21 switching on start. 10:29 RCA18, RCA21 S2 tuning start. 10:54 RCA18, RCA21 tuning end. 10:55 S1 tuning start - first value applied. 11:20 S1 tuning end. 11:22 M1 tuning start. 11:48 M1 tuning end. Nominal bias values applied. 11:49 M2 tuning start. 12:14 M1 tuning end. 12:16 RCA18 4kHz disabled. 12:26 RCA21 4kHz disabled. 12:27 RCA18, RCA21 switch off start. 12:31 RCA18, RCA21 off. 12:35 test end.

Time	Test ID	End Time	Test Log
2008/07/12 12:37	TUN_0069	14:55	RCA19, RCA22 ACA step 1b tuning. 12:44 4kHz switching disabled. 12:48 RCA19,RCA22 off and then starting to switch on. 12:51 RCA19 4kHz enabled. 12:55 RCA19, RCA22 S2 tuning start. 13:21 S2 tuning end. 13:22 S1 tuning start. 13:56 M1 started some minutes ago. 14:14 M2 tuning start. 14:34 recover cryo bias setting in the ACA4. 14:39 last step of RCA19, RCA22. 14:44 RCA22 4kHz switched off. 14:45 switch off FEMs. 14:50 everything off. 14:55 4kHz enabled.
2008/07/12 14:57	TUN_0070	17:14	15:01 Disabled RCA20, RCA22 4kHz. 15:04 RCA23 is off. 15:05 RCA23 is on. 15:12 S2 tuning. 15:38 S1 tuning. 16:04 M1 tuning. 16:30 M2 tuning. 16:57 M2 tuning finished. 17:10 RCAs off. 17:13 RCAs back to nominal.
2008/07/12 17:20	TUN_0071	19:45	17:44 Runing M2 on RCA24 and M1 on RCA25. 18:10 tuning M1 on RCA24 and M2 on RCA25. 19:30 last step
2008/07/12 19:50	TUN_0072	21:55	20:00 tuning M1 on RCA27 and M2 on RCA26. 20:25 tuning M2 on RCA27 and M1 on RCA26. 20:50 tuning S1 on RCA27 and S2 on RCA26. 21:15 tuning S2 on RCA27 and S1 on RCA26.
2008/07/12 22:00	TUN_0073	00:15	22:07 soft switch on RCA28. 22:15 tuning M1 RCA28. 22:40 tuning M2. 23:05 tuning S1. 23:30 tuning S2. 00:00 S2 finished.
2008/07/17 05:36	TUN_0074	08:40	ACA step 2 matrix tuning starts. T = 15.15 K. Test starts at 6:22.
2008/07/17 08:40	TUN_0075	10:55	
2008/07/17 11:00	TUN_0076	13:07	
2008/07/17 13:10	TUN_0077	15:25	
2008/07/17 15:30	TUN_0078	17:48	
2008/07/17 18:00	TUN_0079	20:16	Starting RCA26 M2 and RCA27 M1. Just finished RCA26 M1 and RCA27 M2 and started tuning of RCA26 S2 and RCA26 S1
2008/07/17 20:18	TUN_0080	22:42	Soft switch on of RCA28 initiated. 22:28 Matrix tuning finished and RCA28 FEMs are switched off after disabling 4kHz.
2008/07/19 16:09	TUN_0082	17:35	17:00 Casual switch off of the HPCCS machine. 17:15 SCOS restarted. TUN_0082 closed at 17:35
2008/07/19 17:35	TUN_0083	20:16	ACA step 3 matrix tuning starts. Matrix tuning for RCA18 and RCA21. TUN_0083 closed at 20:16
2008/07/19 20:18	TUN_0084	22:34	Matrix tuning for RCA19 and RCA22. TUN_0084 closed at 22:34
2008/07/19 22:38	TUN_0085	00:50	RCA 20 and 23. TUN_0085 closed at 00:50 (20/07)
2008/07/20 00:50	TUN_0086	03:23	RCA 24 and 25. 01:00 Saturation observed on RCA241S (as expected!). Removal from saturation achieved using the appropriate procedure. As expected RCA24 oscillates during the switch on to nominal bias. TUN_0086 closed at 03:23 (20/07)
2008/07/20 03:25	TUN_0087	05:48	RCA 26 and 27. TUN_0087 closed at 05:48
2008/07/20 05:49	TUN_0088	08:35	RCA 28. TUN_0088 closed at 08:35

The test data useful for data analysis is reported in the following table which includes also the time window of the test, relevant for data analysis.

RCA ID	Test ID(High Tref) Test ID (Low Tref)	Time start	Time end
RCA18,21	TUN_0057	1594161711.62	1594168258.36
	TUN_0083	1595175338.12	1595181843.29
RCA19,22	TUN_0058	1594169466.22	1594175963.29
	TUN_0084	1595183477.21	1595189989.50
RCA20,23	TUN_0059	1594177347.18	1594183864.91
	TUN_0085	1595191753.29	1595198234.74
RCA24,25	TUN_0060 (TUN_0078)**	1594185209.19*	1594191700.02*
	TUN_0086	1595200512.76	1595206945.27
RCA26,27	TUN_0060	1594193179.81	1594199637.76
	TUN_0087	1595209504.23	1595215932.51
RCA28	TUN_0060 (TUN_0073)**	1594201048.60	1594207386.02
	TUN_0088	1595219029.08	1595225237.60

(*) Different time windows were chosen for different amplifiers in order to select proper biases.
(**) As discussed above, for the RCA 24 S1,S2 and RCA28 S1,S2 different dasets were used.

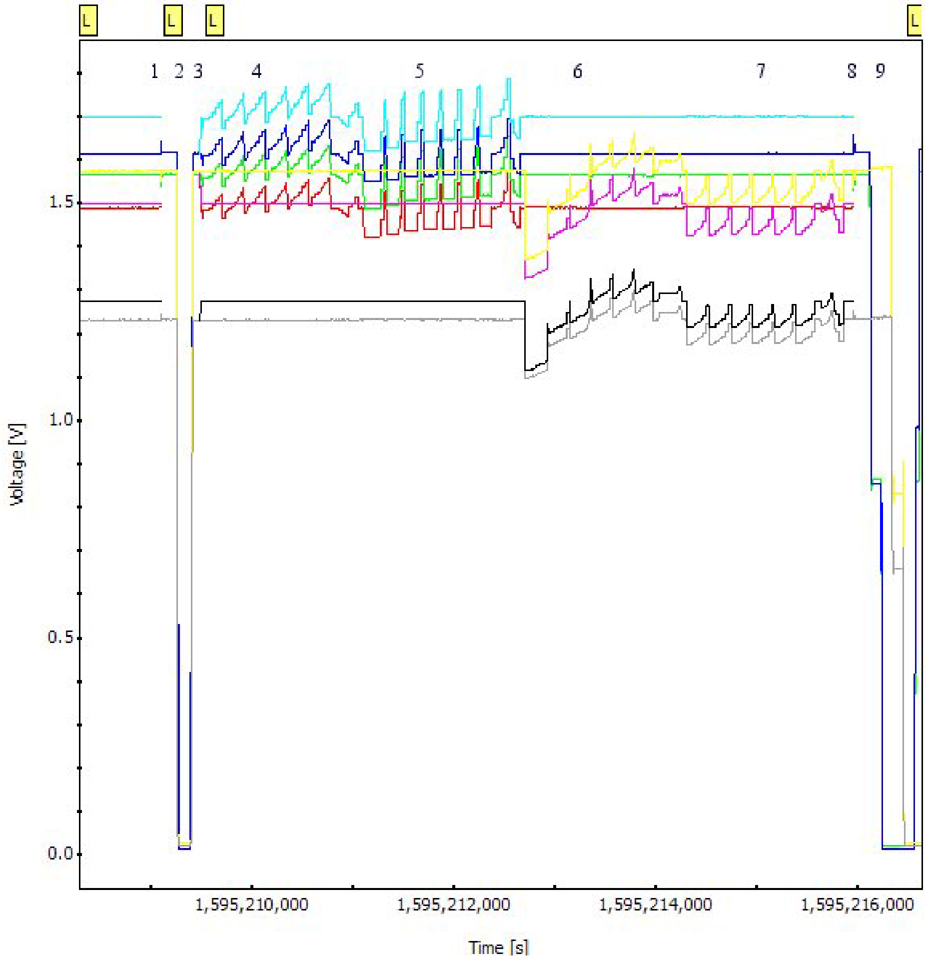


Figure 1: Lama_view graphical display of theRCA27 during TUN_0087 test.

In the Figure 1 a typical procedure ([AD5]) for a matrix tuning dataset is shown. Nine main steps are performed and visible in the plot:

1. 4KHz switching is disabled
2. FEMs under test are switched off
3. FEMs under test are switched on again and 4KHz switching enabled
4. First ACA matrix tuning is performed
5. First ACA is put back at its nominal biases and second ACA matrix tuning is performed
6. Second ACA is put back at its nominal biases and third ACA matrix tuning is performed
7. Third ACA is put back at its nominal biases and fourth ACA matrix tuning is performed
8. 4KHz switching is disabled
9. FEMs under test are switched off then switched on again and 4KHz switching enabled

6 DATA ANALYSIS AND RESULTS

Data analysis has been performed using dedicated routines within the `LIFE_OM` environment. Specifically the following IDL programs have been used (only relevant programs for this test are listed):

Lama_tune_vg1vg2.pro	Main program to identify the House keeping parameter, extract scientific data, perform calculation and send to output the data structure and create a report
Select_matrix_tuning_jump.pro	Main program to identify time windows in data fits files as the housekeeping parameters changes
CSL_Input_ACA_Tuning_Step1_4.pro	Script to run the above programs
Display_Matrix_result.pro	Creates detailed contour plots containing also values visualization and surface plot option

All these programs are under CVS and distributed with the LIFE_OM packages. Obviously the script can be changed as needed.

In the next sections, the data analysis performed at CSL – Liege is reported and results of this analysis have been used to decide the best ACA VG1 and VG2 biases for the next tests.
A first run of data analysis was performed at CSL – Liege to provide the best tuned biases for next level tests. This analysis, mainly based on automatic routine `lama_tune_vg1vg2.pro.`
Some singularities and discontinuities in the values were found and displayed in the result plot.
This did not affect the correct selection of biases because it was decide to choose minimum values within smoot and regular regions of the contour plots used to display results. In these cases the surface plot visualization was very useful. More discussion and examples on this is found in the comment section below.

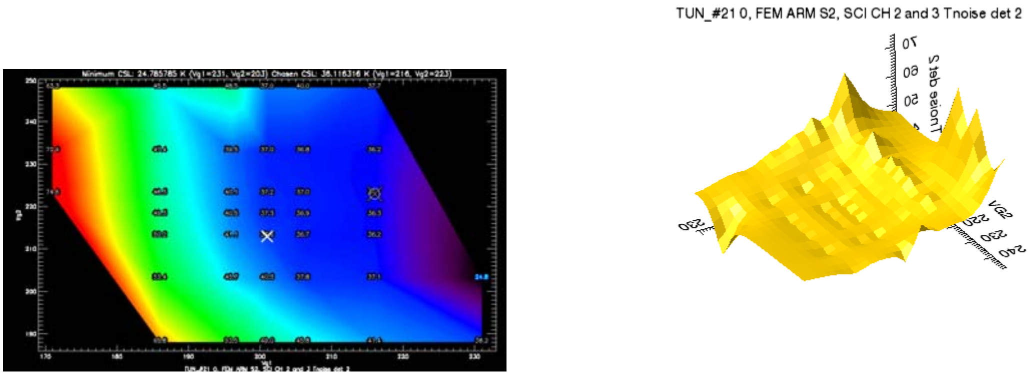


Figure 2: *Typical contour plot of the ACA bias matrix tuning (left plot) and corresponding surface plot (right plot); it is evident as the dark blue minimum point at the right of the contour is a singularity minimum due to some fake effect in the selected data (see also[RD6]*

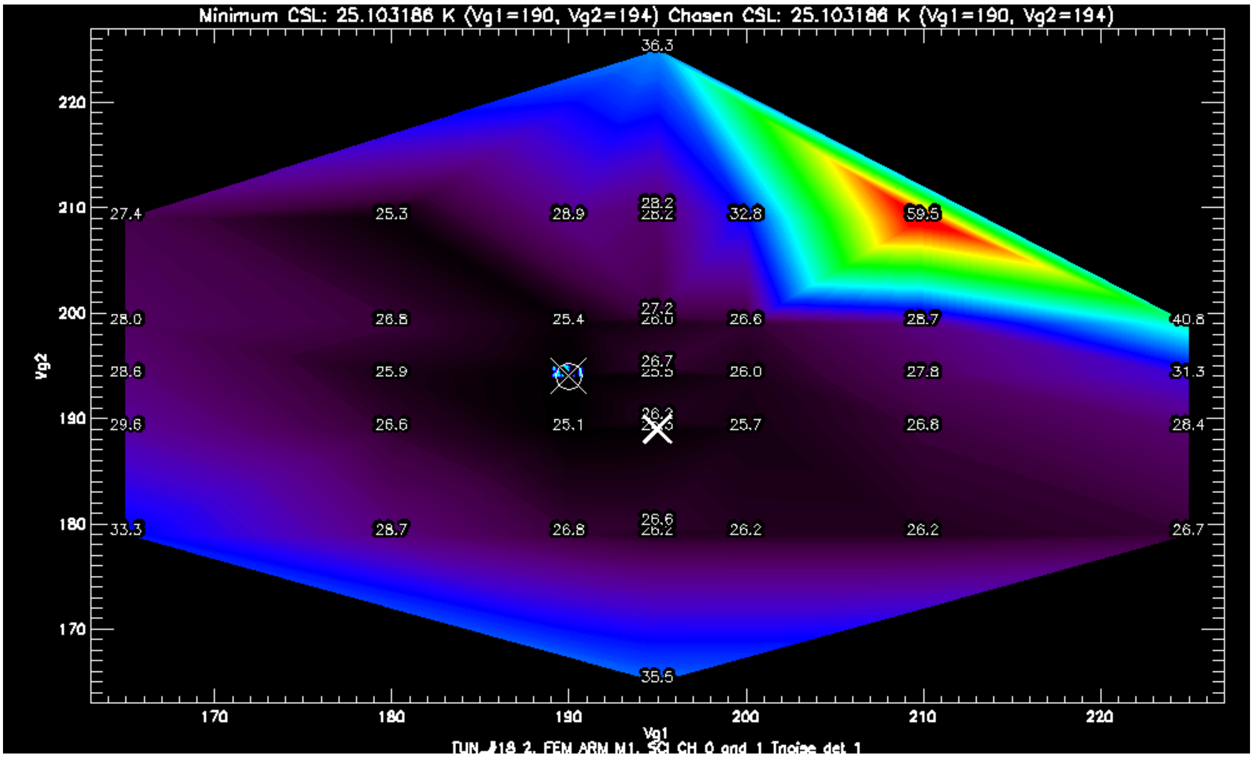
The final results are reported in *Table 1.*

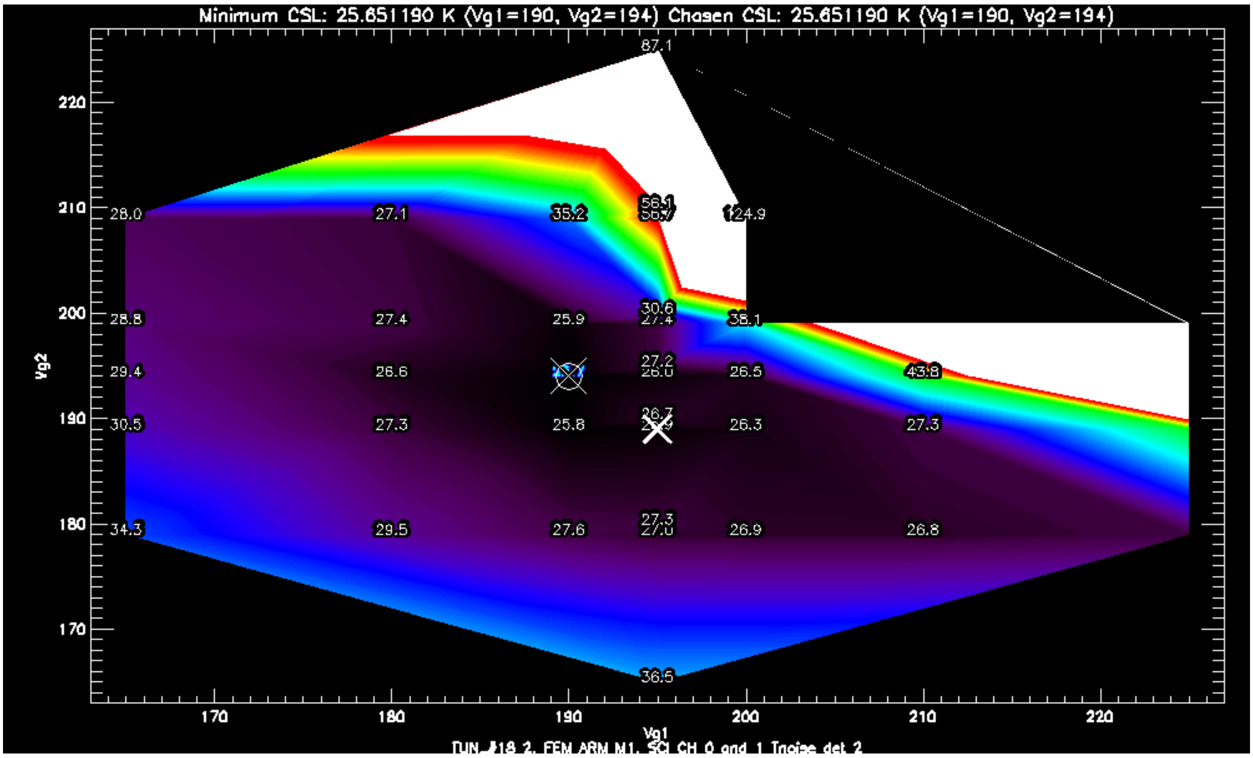
Table 1: Bias Values as derived from the ACA matrix tuning test and used for the continuation of the CSL campaign

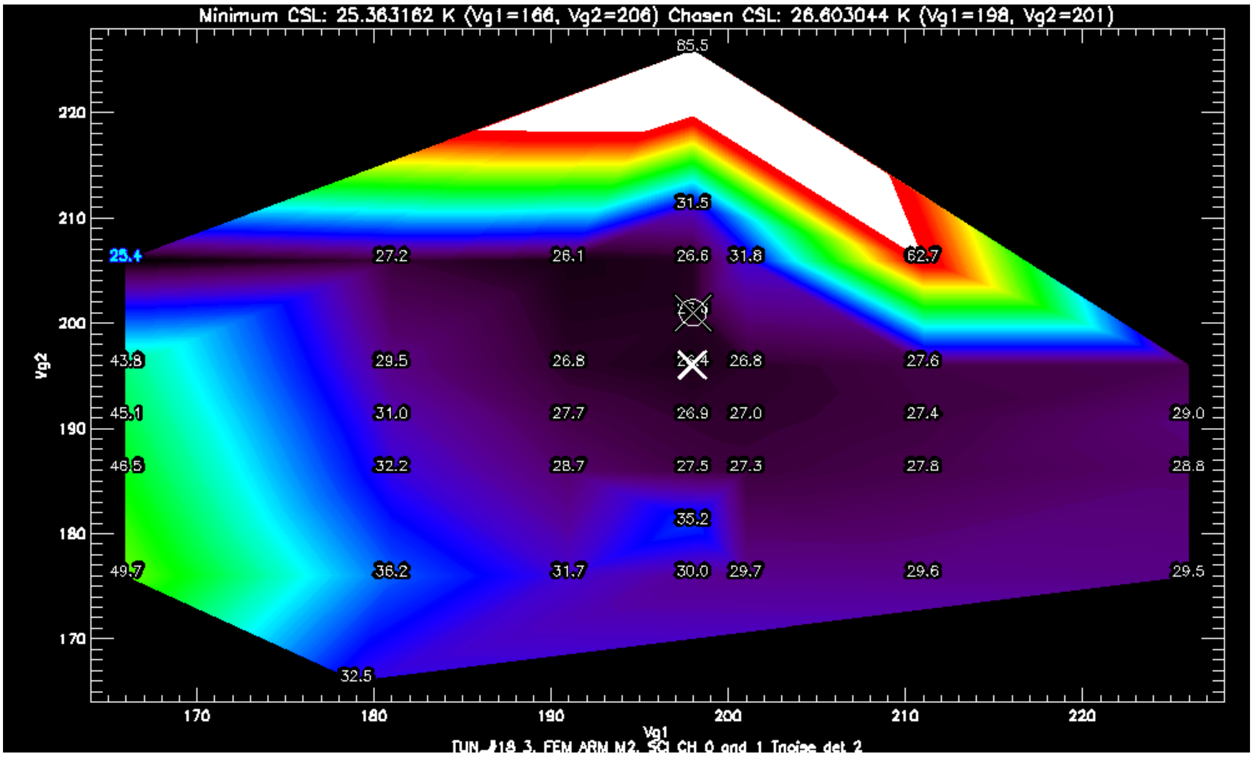
	M1		M2		S1		S2	
	Vg1	Vg2	Vg1	Vg2	Vg1	Vg2	Vg1	Vg2
#18	195	189	198	196	200	196	200	204
#19	215	198	220	196	215	204	220	201
#20	225	204	231	206	210	211	198	201
#21	201	207	210	187	196	197	201	213
#22	179	204	178	176	204	184	220	199
#23	223	182	226	195	197	166	186	223
#24	226	204	227	204	219	213	219	225
#25	222	221	224	212	226	216	219	220
#26	232	221	232	219	228	226	232	217
#27	240	108	245	108	238	86	250	126
#28	243	101	240	112	235	88	245	121

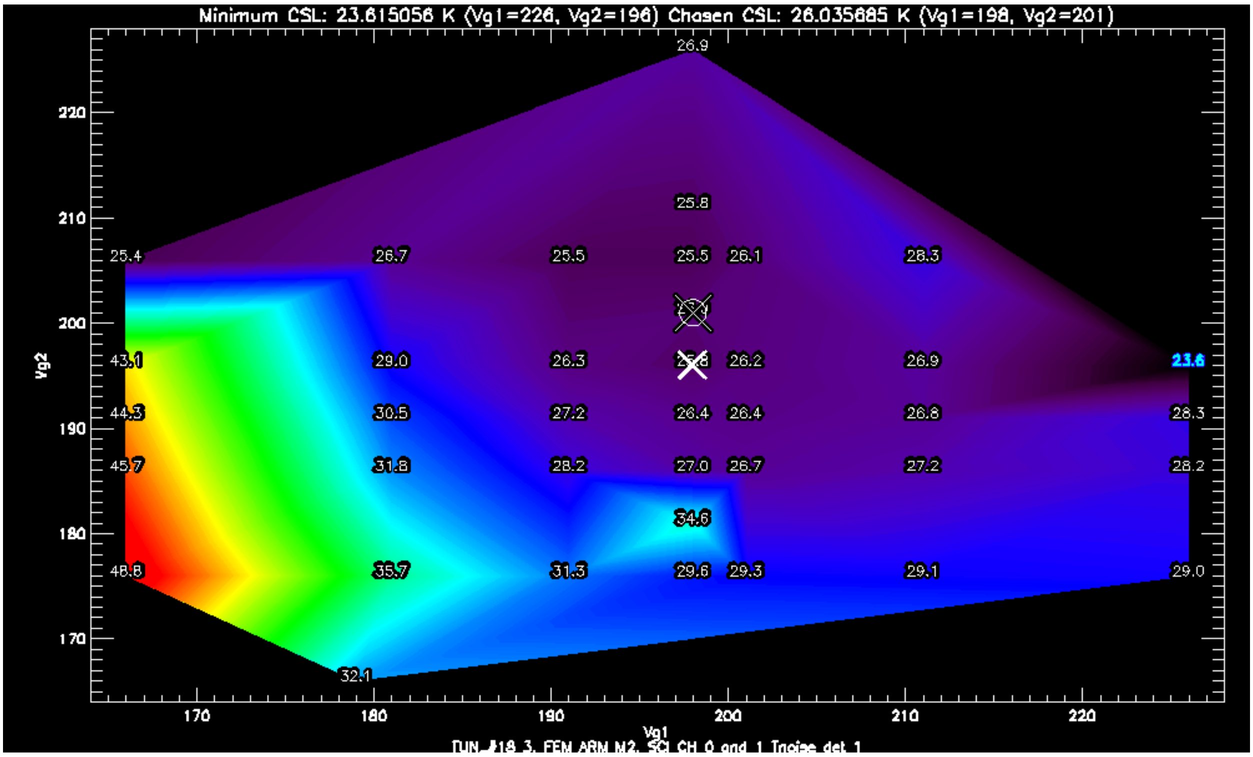
In the following the noise temperature contour plots for all the amplifiers (two plots each, referring to the two detectors associated to the amplifiers) are shown with values written on the points to have a better view of the results. Minimum found is in light blue, the chosen value is highlighted with a circle and cross, the old RAA value is highlighted with an X.
When the results were flat and no major differences were found, as for instance in the 30 GHz channels, often the RAA values were preferred.
Further details about the data analysis can be found in the annexed reports generated by the Lama tool.

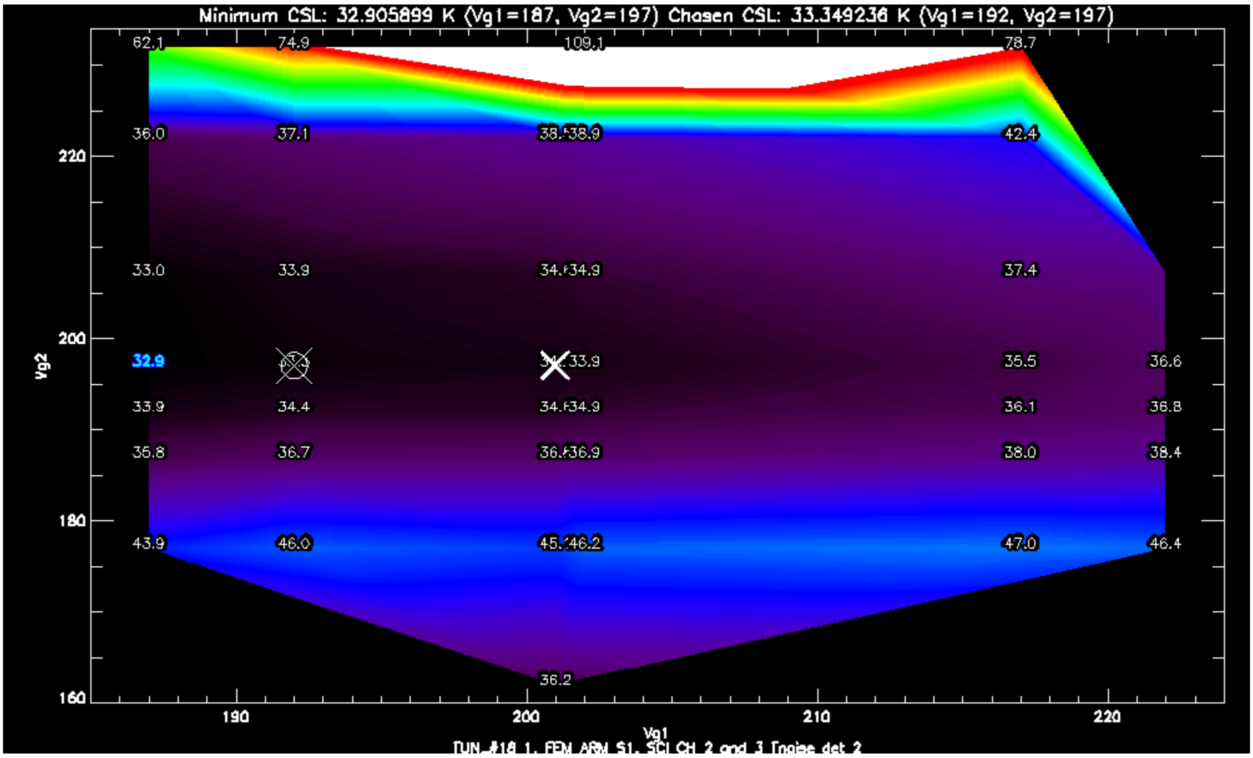
6.1.1 RCA18 Contour Plots

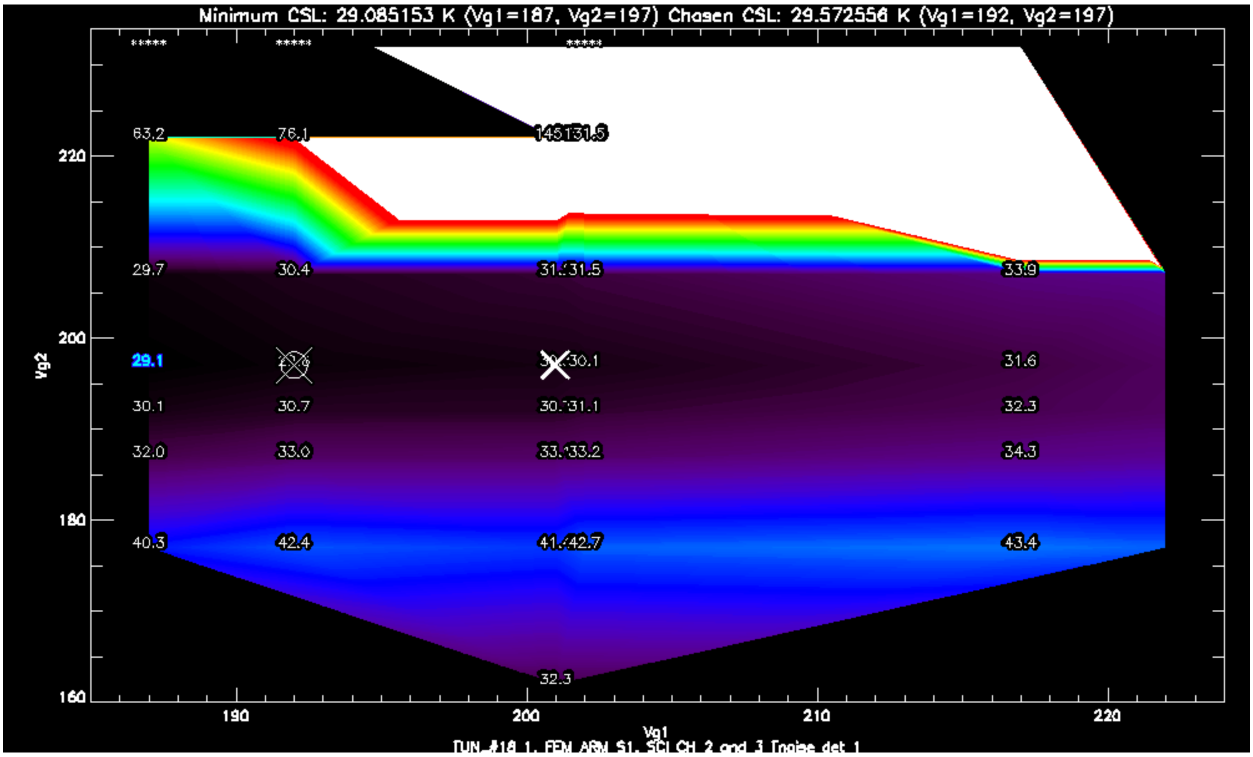


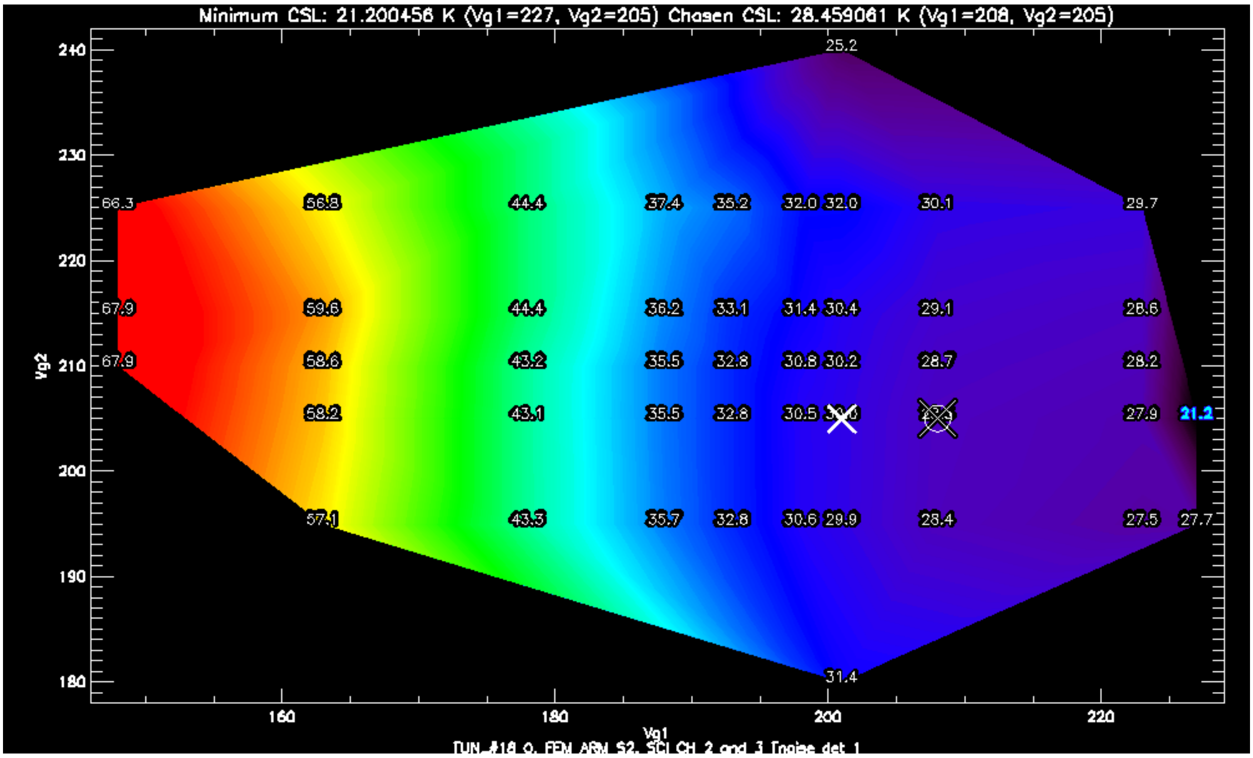


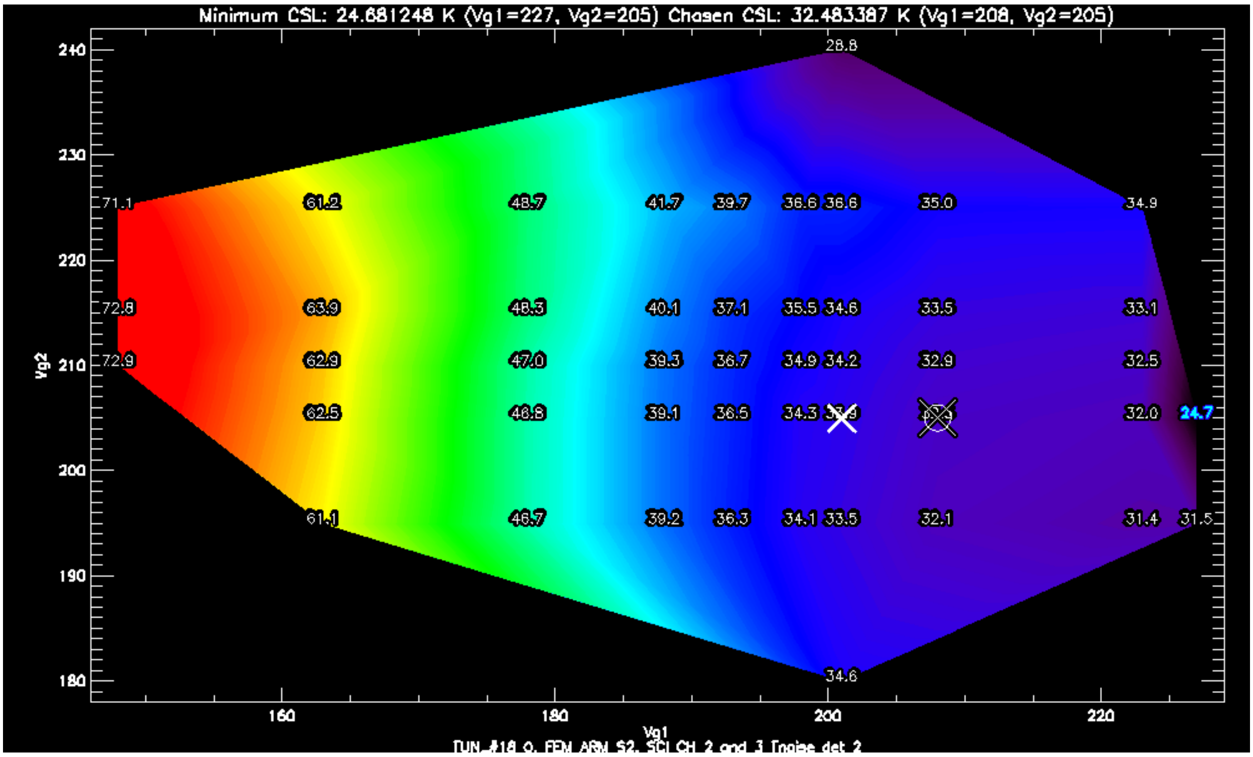

Minimum CSL: 25.363162 K (Vg1=166, Vg2=206) Chosen CSL: 26.603044 K (Vg1=198, Vg2=201)
Vg2
Vg1
170
180
190
200
210
220
85.5
31.5
25.4
27.2
26.1
26.6
31.8
62.7
43.8
29.5
26.8
26.8
27.6
45.1
31.0
27.7
26.9
27.0
27.4
29.0
46.5
32.2
28.7
27.5
27.3
27.8
28.8
35.2
49.7
36.2
31.7
30.0
29.7
29.6
29.5
32.5


Minimum CSL: 23.615056 K (Vg1=226, Vg2=196) Chosen CSL: 26.035685 K (Vg1=198, Vg2=201)
Vg2
Vg1
170
180
190
200
210
220
26.9
25.8
25.4
26.7
25.5
25.5
26.1
28.3
43.1
29.0
26.3
26.2
26.9
23.6
44.3
30.5
27.2
26.4
26.4
26.8
28.3
45.7
31.8
28.2
27.0
26.7
27.2
28.2
34.6
48.8
35.7
31.3
29.6
29.3
29.1
29.0
32.1

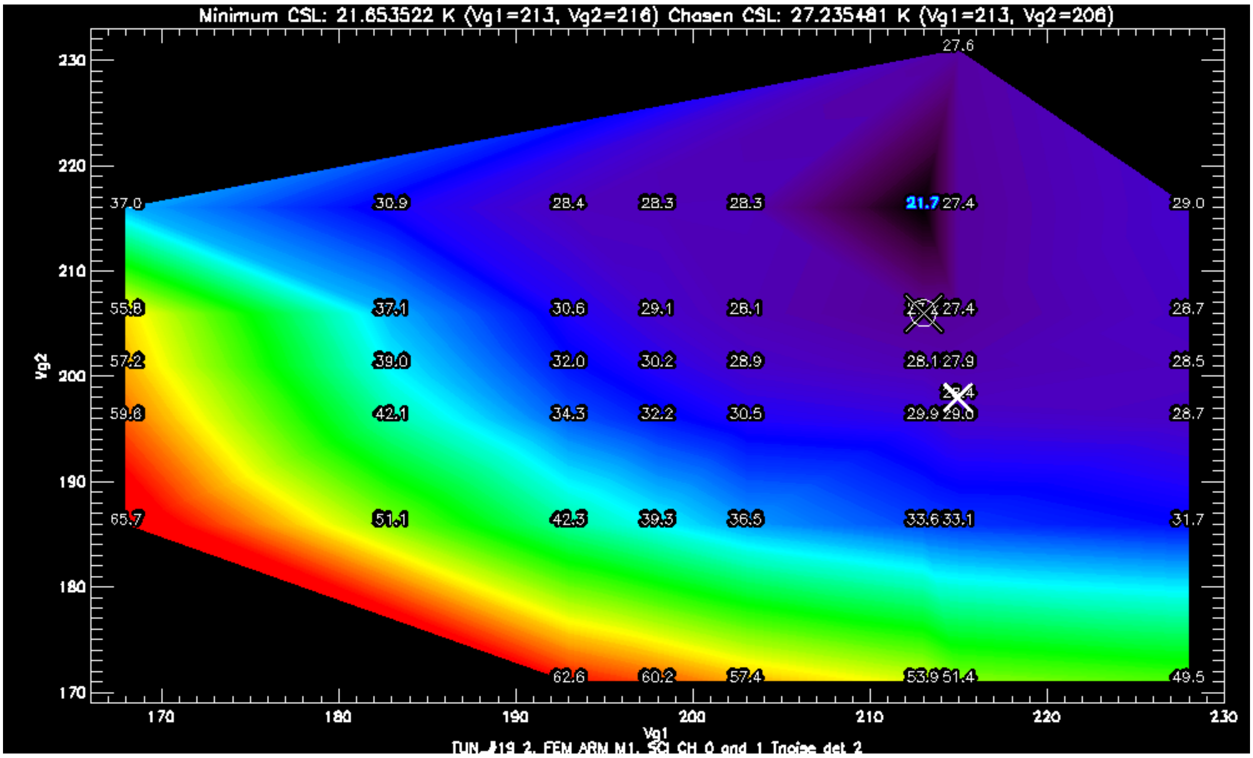

Minimum CSL: 32.905899 K (Vg1=187, Vg2=197) Chosen CSL: 33.349236 K (Vg1=192, Vg2=197)
Vg2
220
200
180
160
190
200
210
220
Vg1
TUN_#18 1. FEM ARM S1. SCI CH 2 and 3 [noise det 2

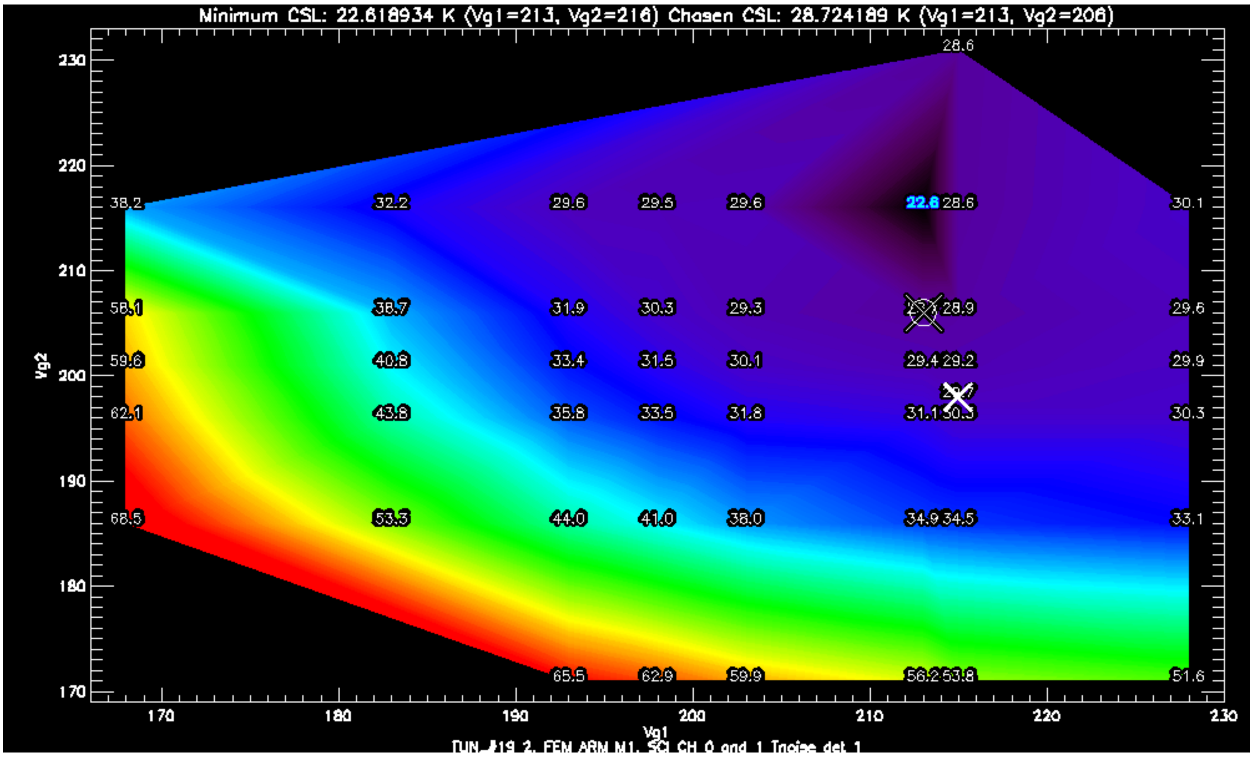

Minimum CSL: 29.085153 K (Vg1=187, Vg2=197) Chosen CSL: 29.572556 K (Vg1=192, Vg2=197)
Vg2
220
200
180
160
190
200
210
220
Vg1
TUN_#18 1. FEM ARM S1. SCI CH 2 and 3 [noise det 1

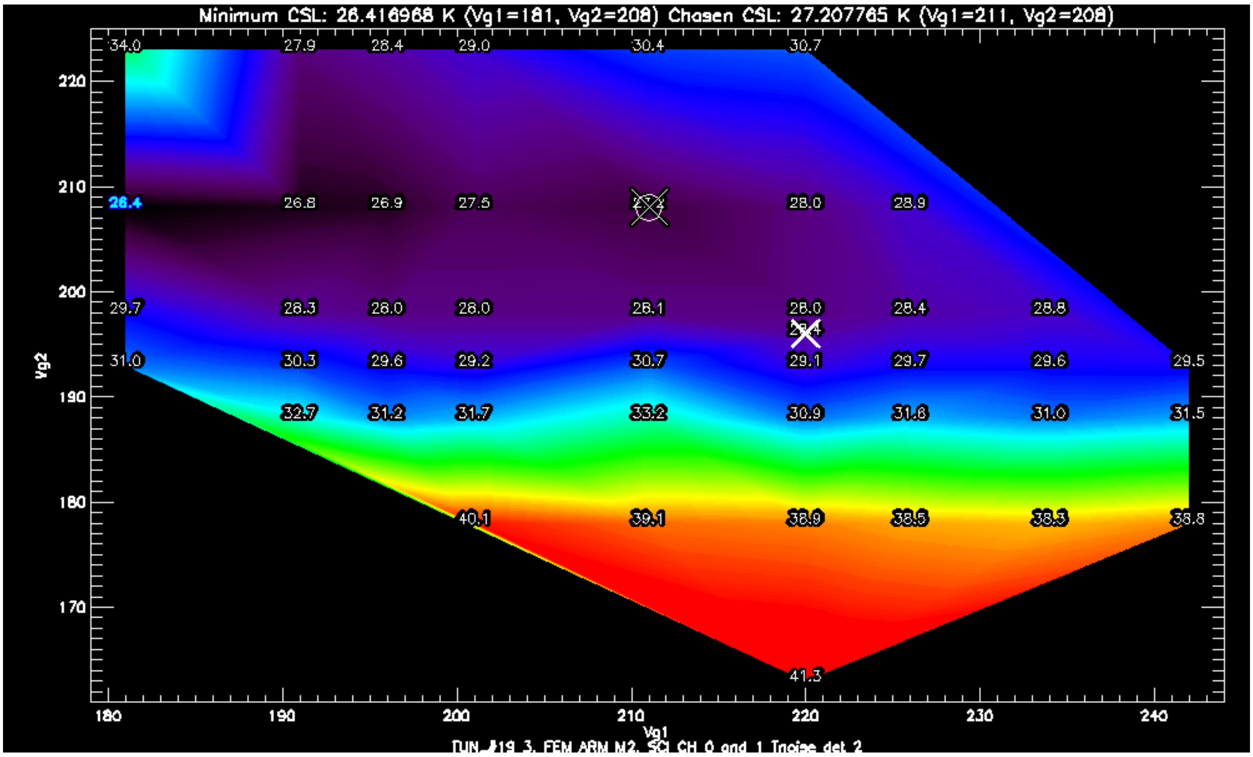

Minimum CSL: 21.200456 K (Vg1=227, Vg2=205) Chosen CSL: 28.459061 K (Vg1=208, Vg2=205)
Vg2
Vg1
TUN_#18 0, FEM ARM S2, SCI CH 2 and 3 fnoise det 1

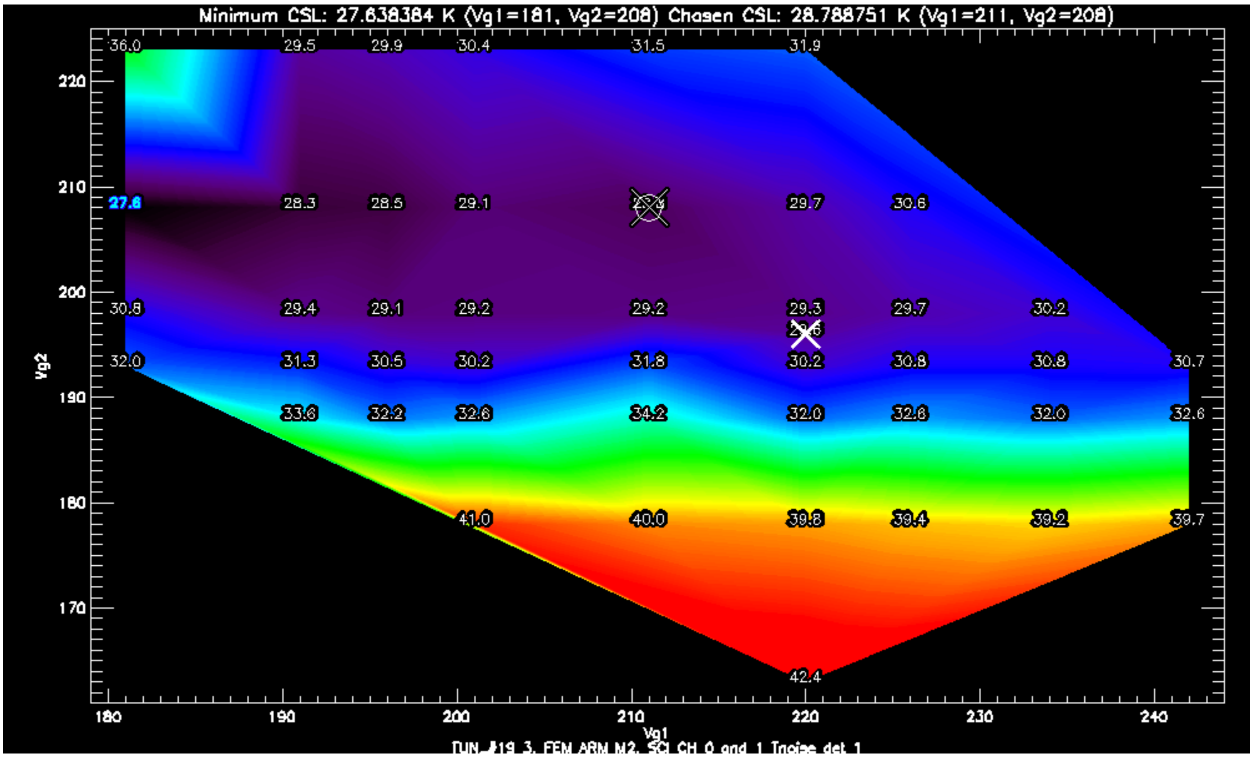

Minimum CSL: 24.681248 K (Vg1=227, Vg2=205) Chosen CSL: 32.483387 K (Vg1=208, Vg2=205)
Vg2
Vg1
TUN_#18 0, FEM ARM S2, SCI CH 2 and 3 fnoise det 2

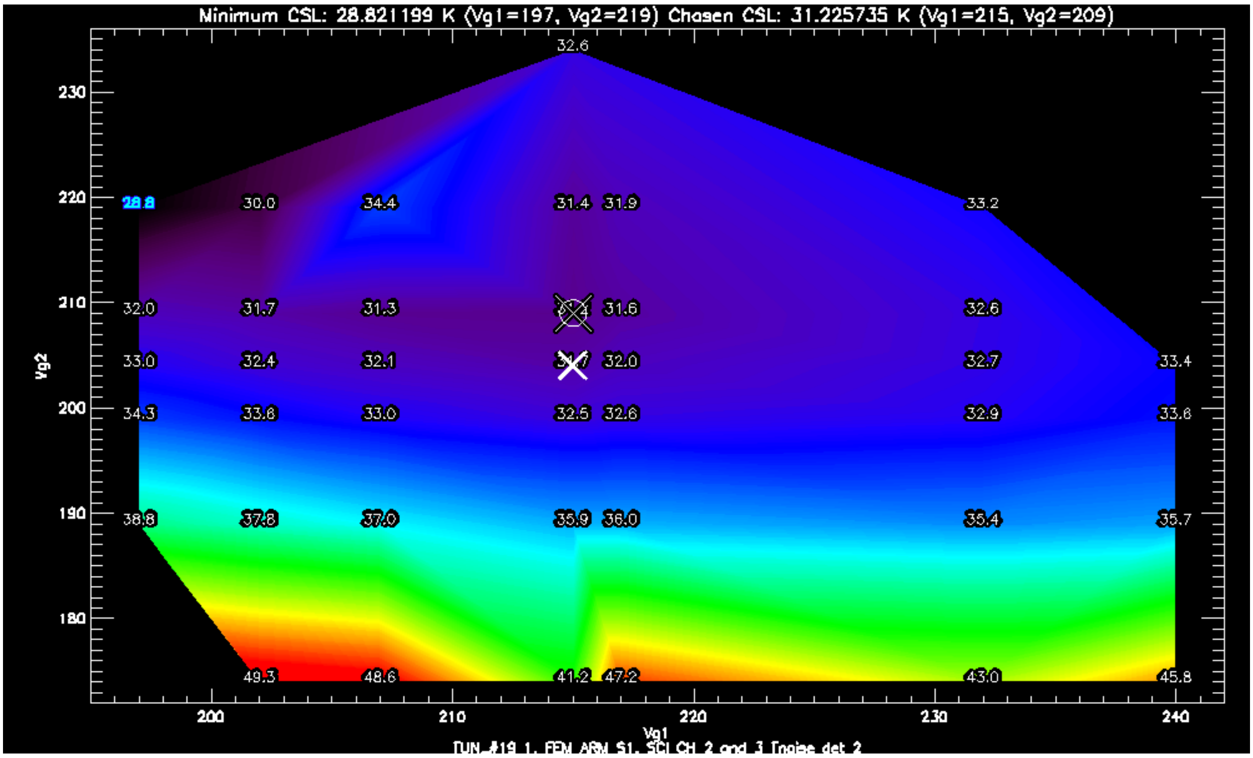
6.1.2 RCA19 Contour Plots

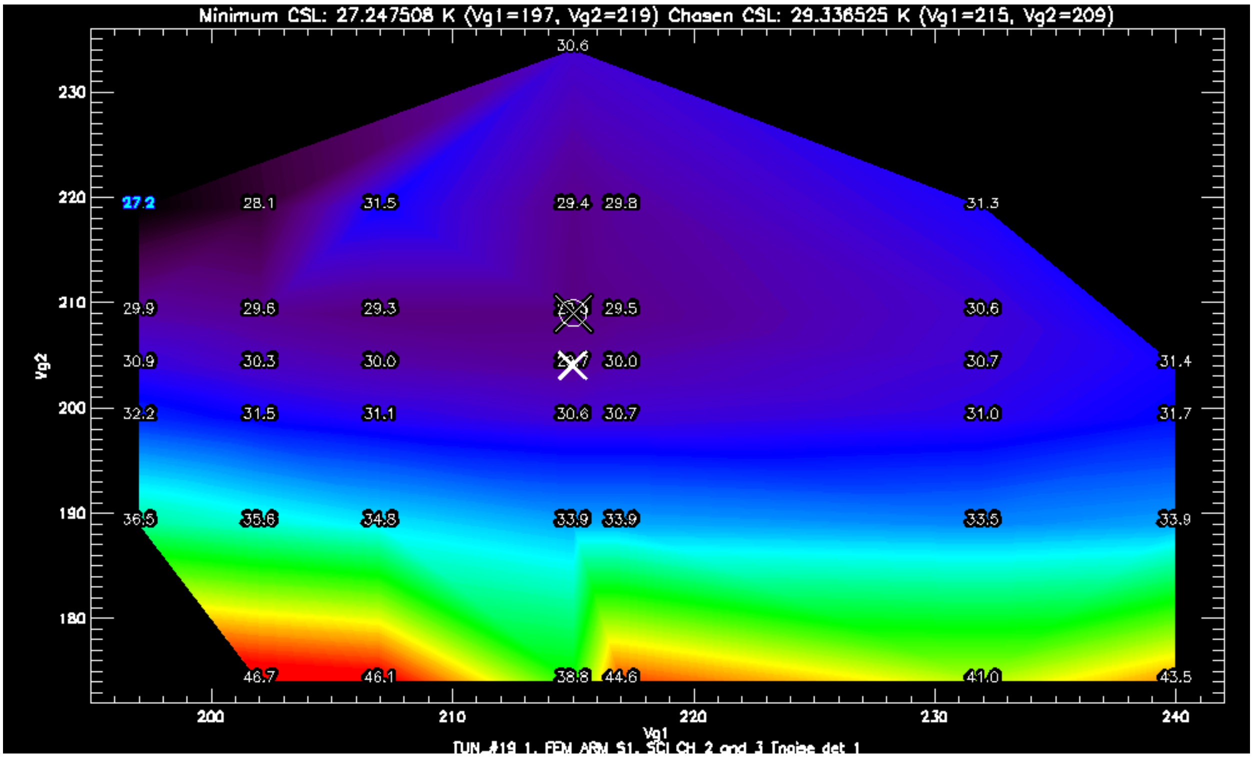


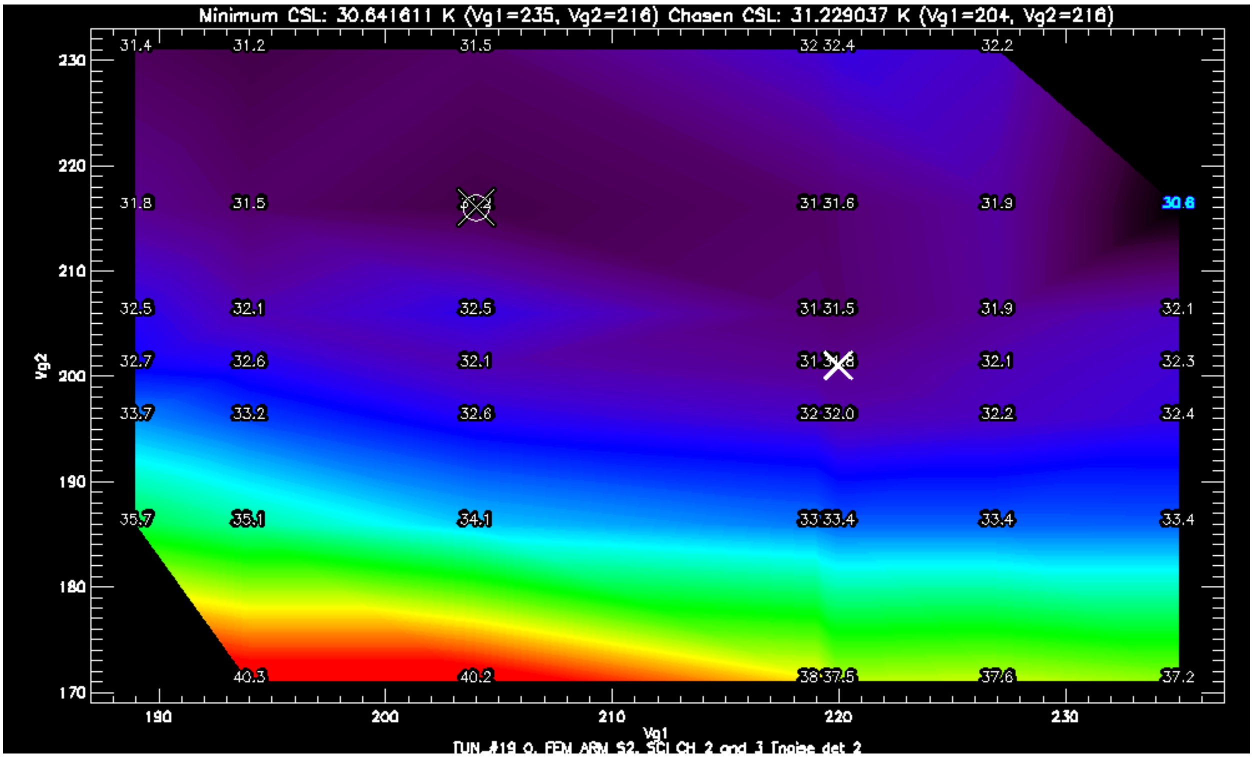


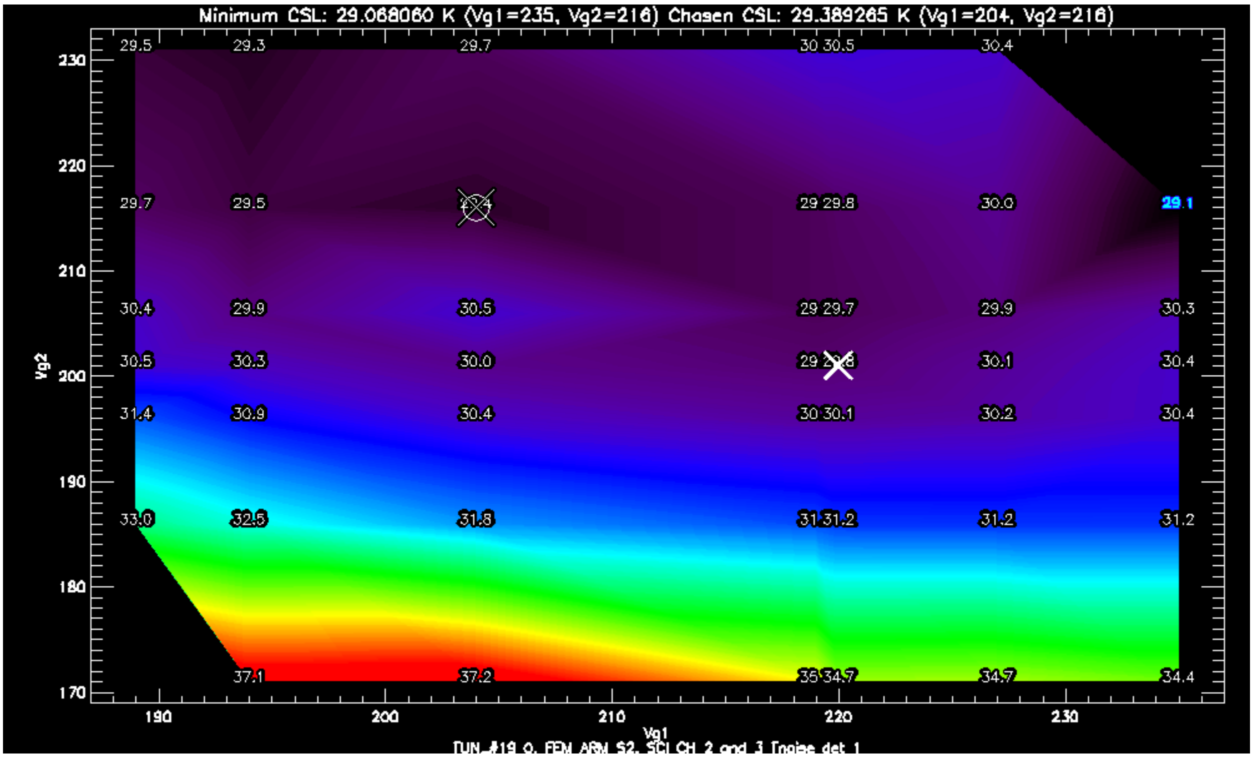

Minimum CSL: 26.416968 K (Vg1=181, Vg2=208) Chosen CSL: 27.207765 K (Vg1=211, Vg2=208)
Vg2
Vg1
TUN_#19_3, FEM ARM M2, SCI CH 0 and 1 Tnoise det 2


Minimum CSL: 27.638384 K (Vg1=181, Vg2=208) Chosen CSL: 28.788751 K (Vg1=211, Vg2=208)
Vg2
Vg1
TUN_#19_3, FEM ARM M2, SCI CH 0 and 1 Tnoise det 1

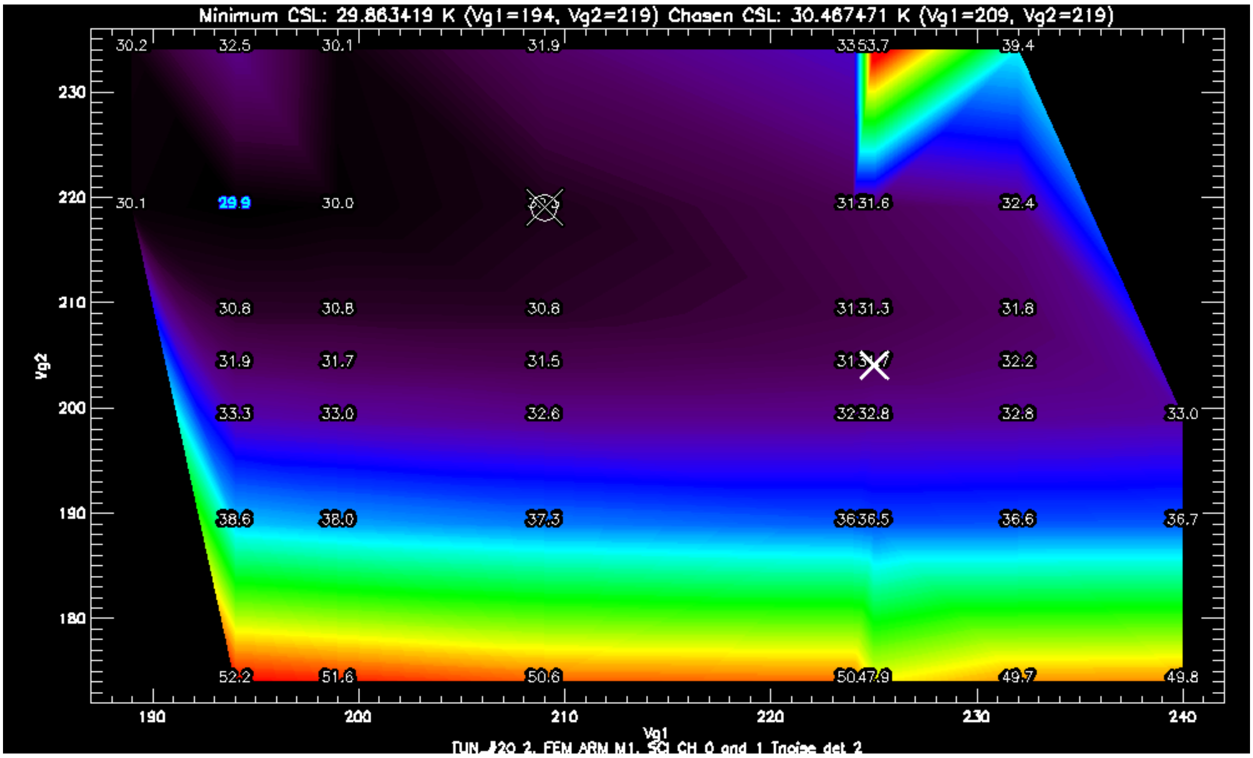

Minimum CSL: 28.821199 K (Vg1=197, Vg2=219) Chosen CSL: 31.225735 K (Vg1=215, Vg2=209)
Vg2
Vg1
TUN_#19 1. FEM ARM S1. SCI CH 2 and 3 Tnoise det 2

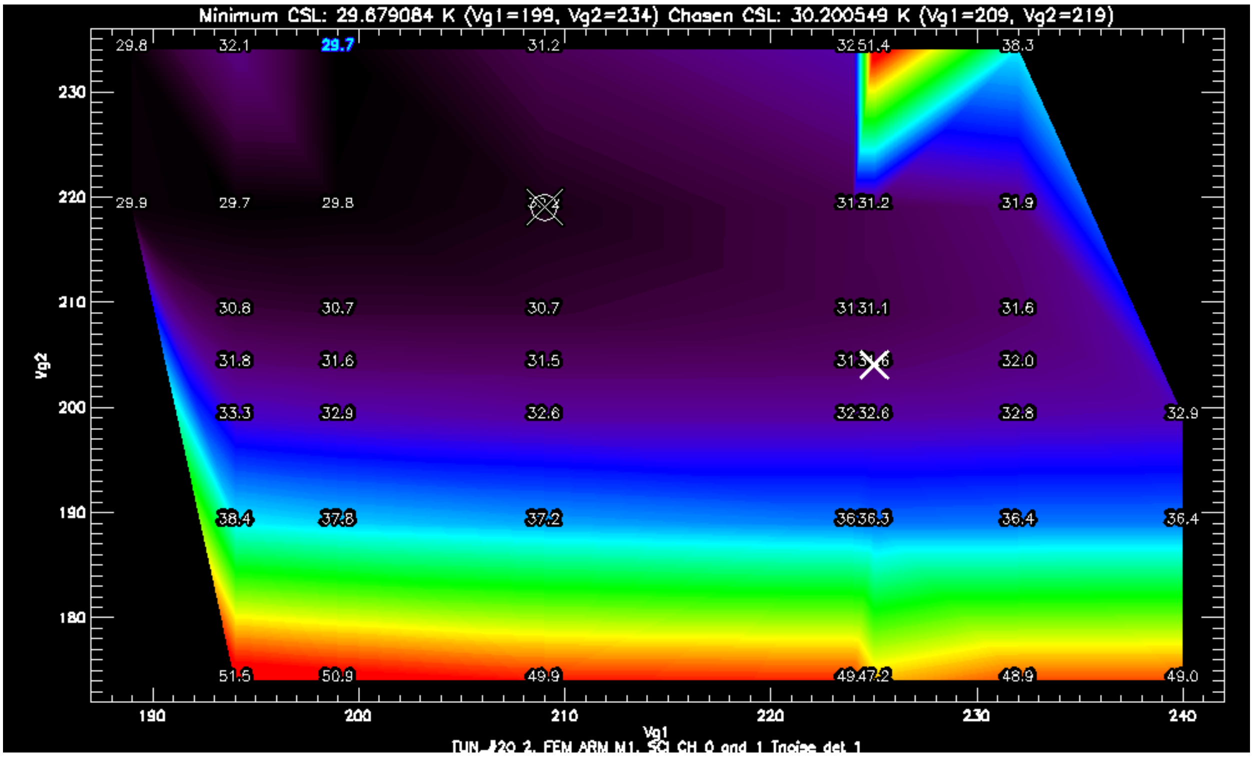

Minimum CSL: 27.247508 K (Vg1=197, Vg2=219) Chosen CSL: 29.336525 K (Vg1=215, Vg2=209)
Vg2
Vg1
TUN_#19 1. FEM ARM S1. SCI CH 2 and 3 Tnoise det 1

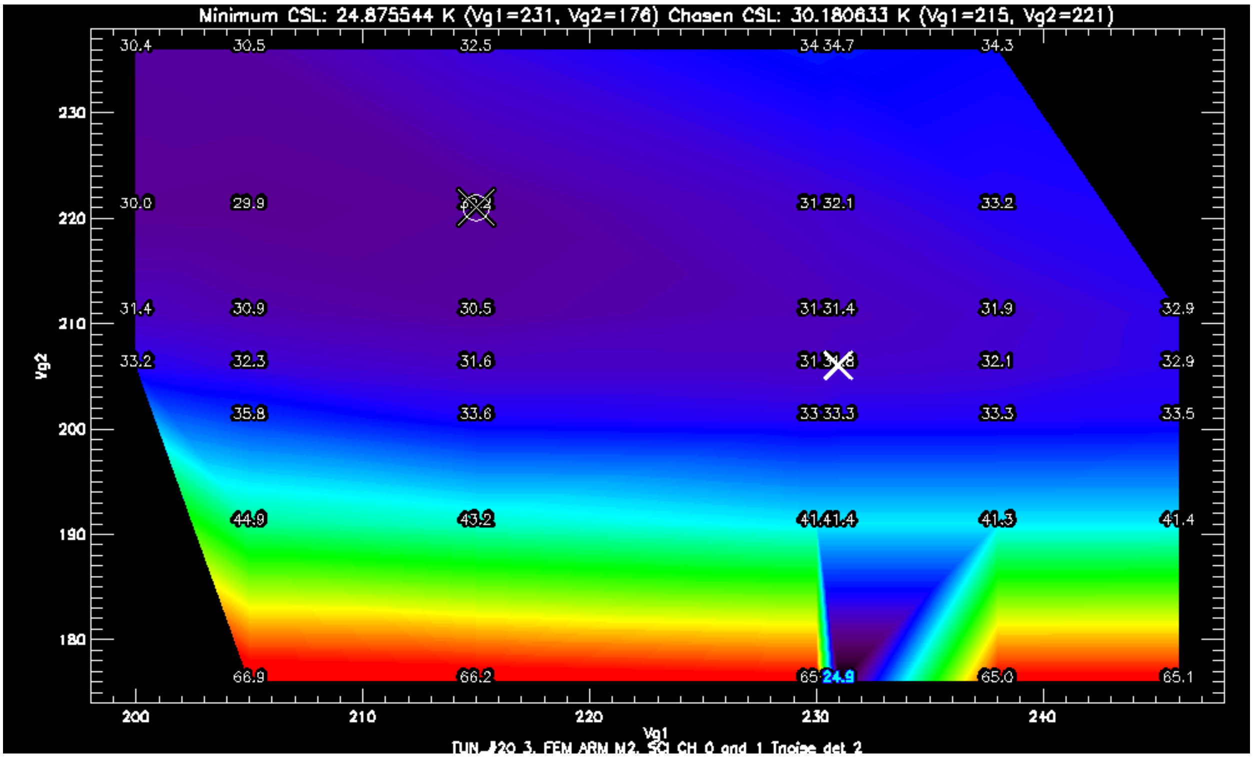

Minimum CSL: 30.641611 K (Vg1=235, Vg2=216) Chosen CSL: 31.229037 K (Vg1=204, Vg2=216)
Vg2
Vg1
TUN_#19 0. FEM ARM S2, SCI CH 2 and 3 [noise det 2

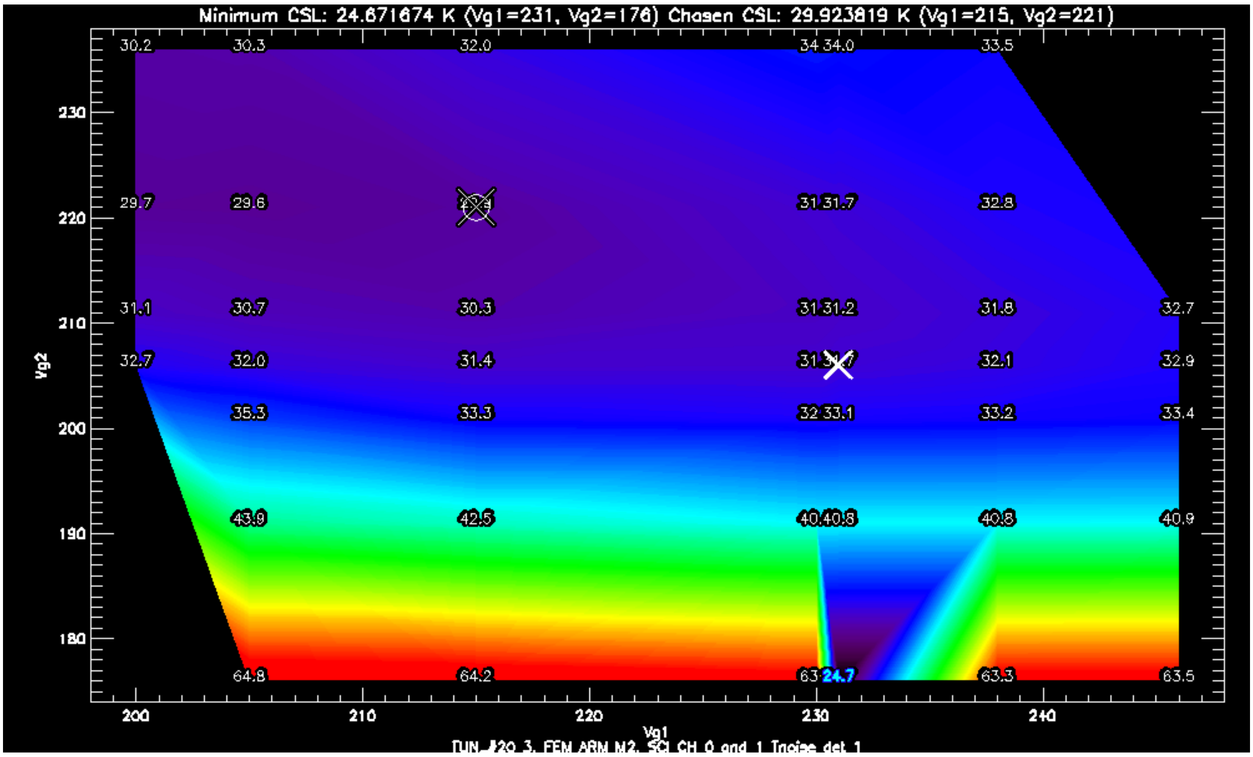

Minimum CSL: 29.068060 K (Vg1=235, Vg2=216) Chosen CSL: 29.389265 K (Vg1=204, Vg2=216)
Vg2
Vg1
TUN_#19 0. FEM ARM S2, SCI CH 2 and 3 [noise det 1

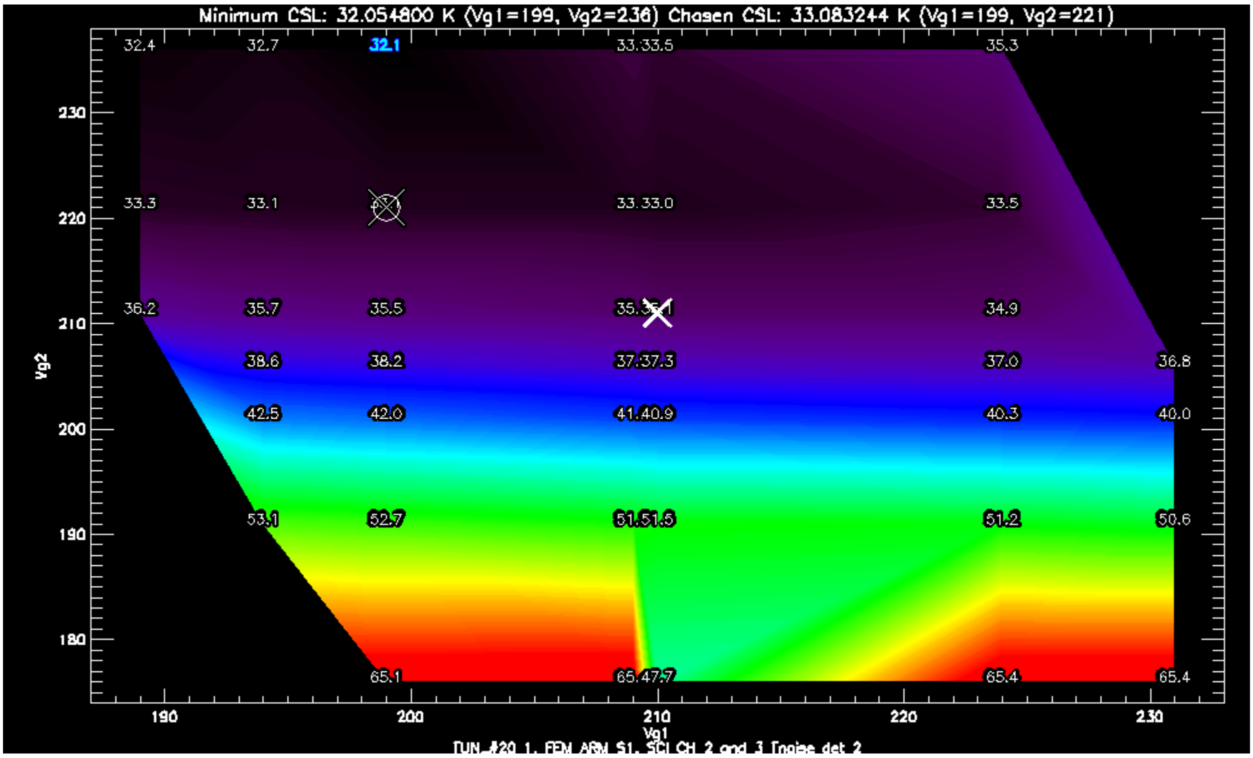
6.1.3 RCA20 Contour Plots

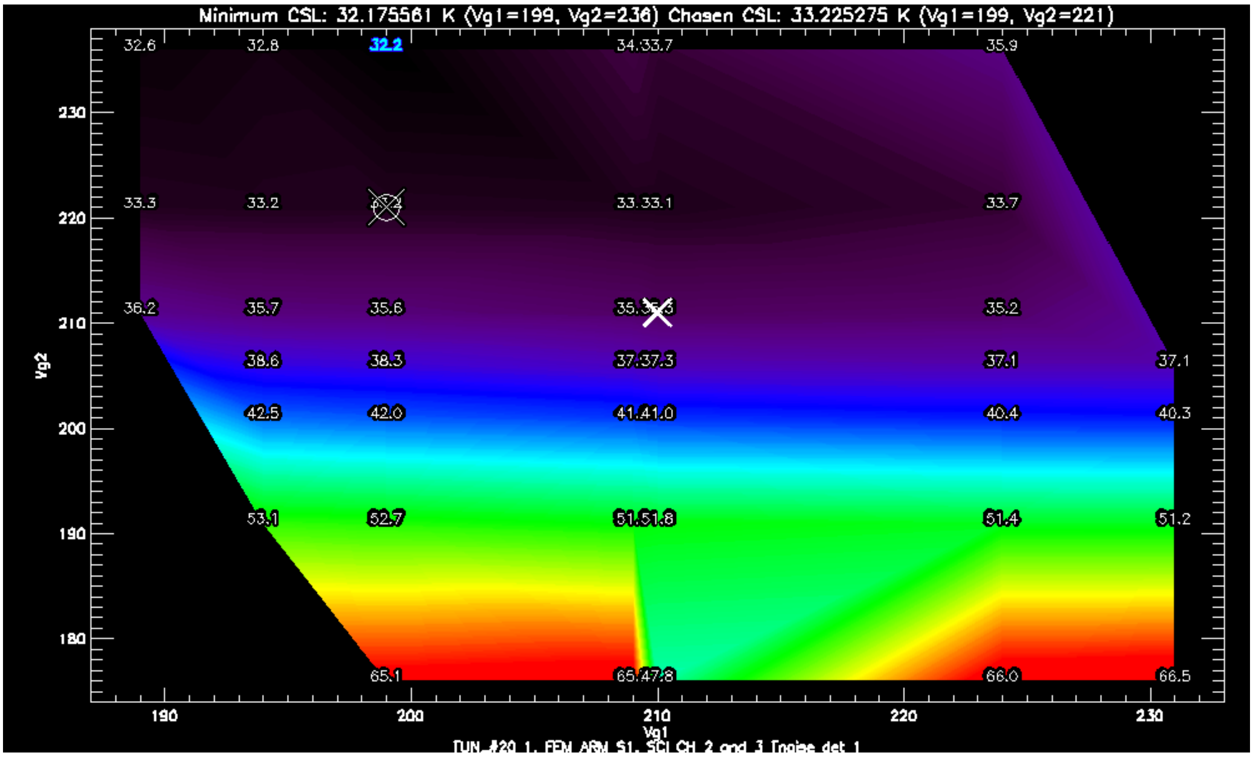


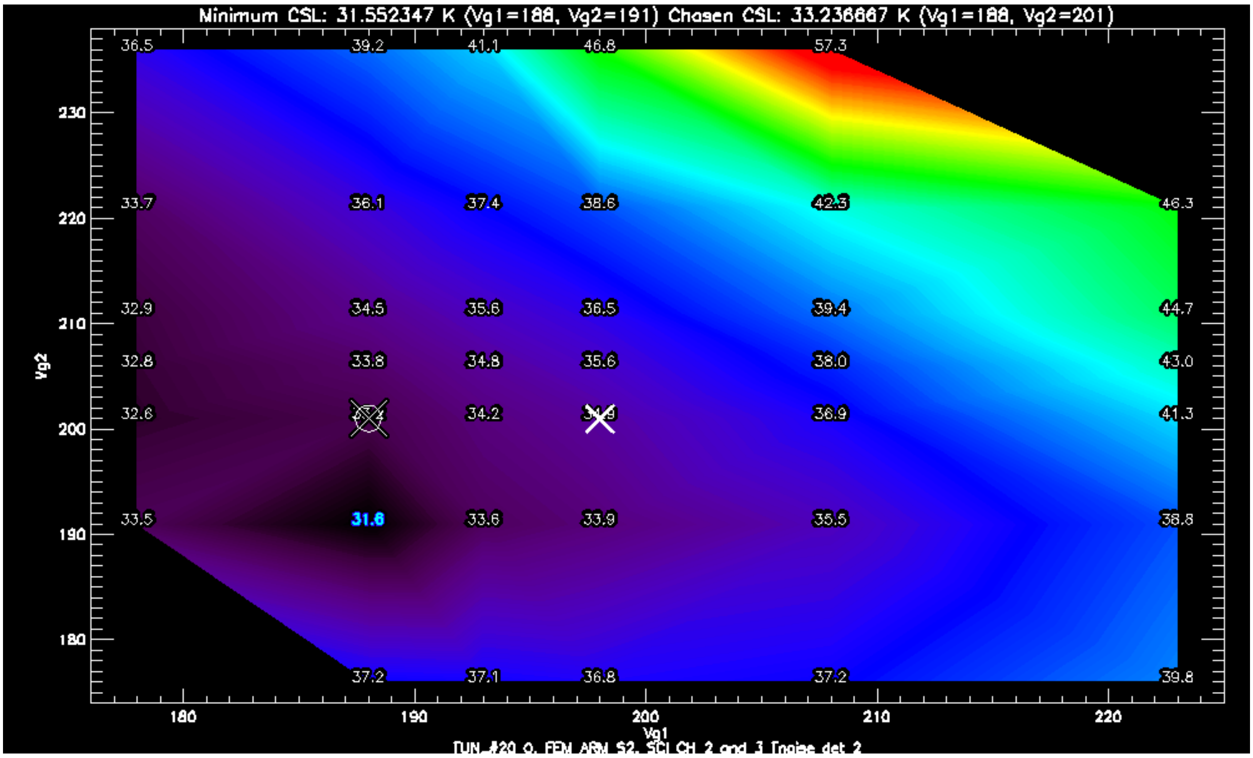


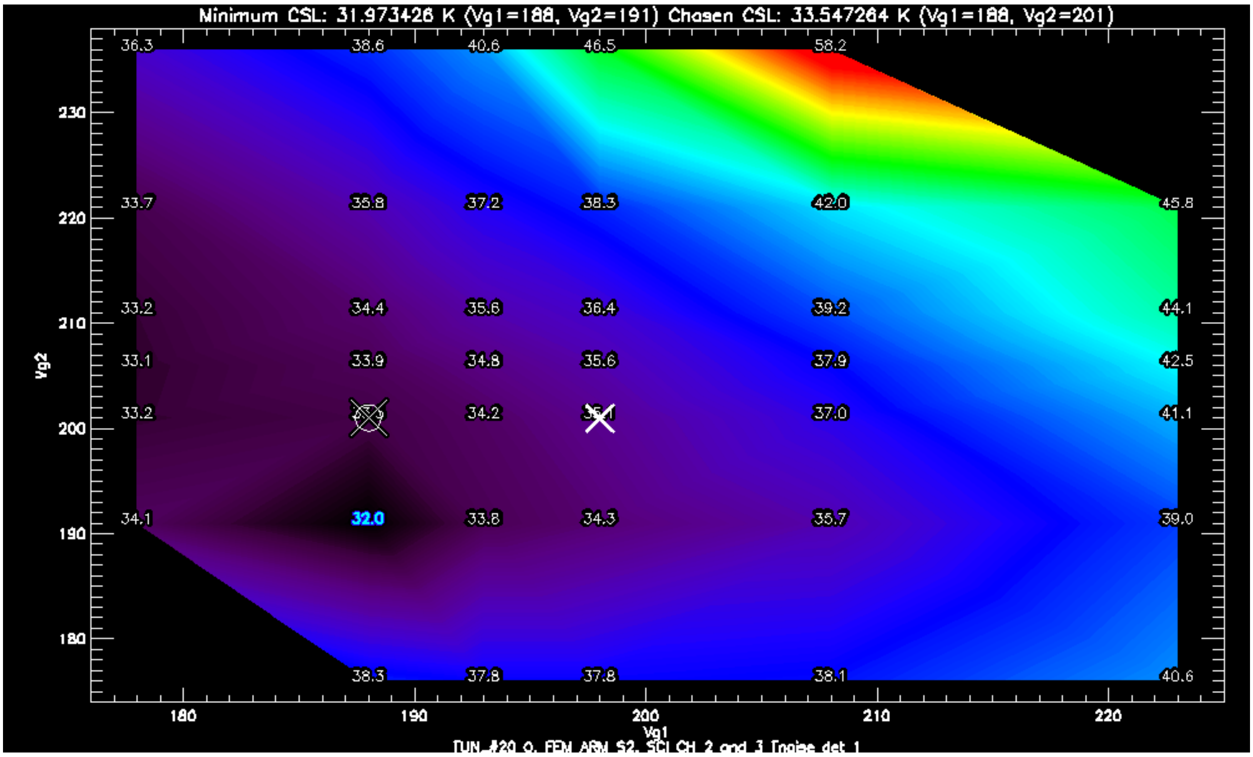

Minimum CSL: 24.875544 K (Vg1=231, Vg2=176) Chosen CSL: 30.180633 K (Vg1=215, Vg2=221)
Vg2
Vg1
200
210
220
230
240
180
190
200
210
220
230
TUN_#20 3, FEM ARM M2, SCI CH 0 and 1 Tnoise det 2


Minimum CSL: 24.671674 K (Vg1=231, Vg2=176) Chosen CSL: 29.923819 K (Vg1=215, Vg2=221)
Vg2
Vg1
200
210
220
230
240
180
190
200
210
220
230
TUN_#20 3, FEM ARM M2, SCI CH 0 and 1 Tnoise det 1

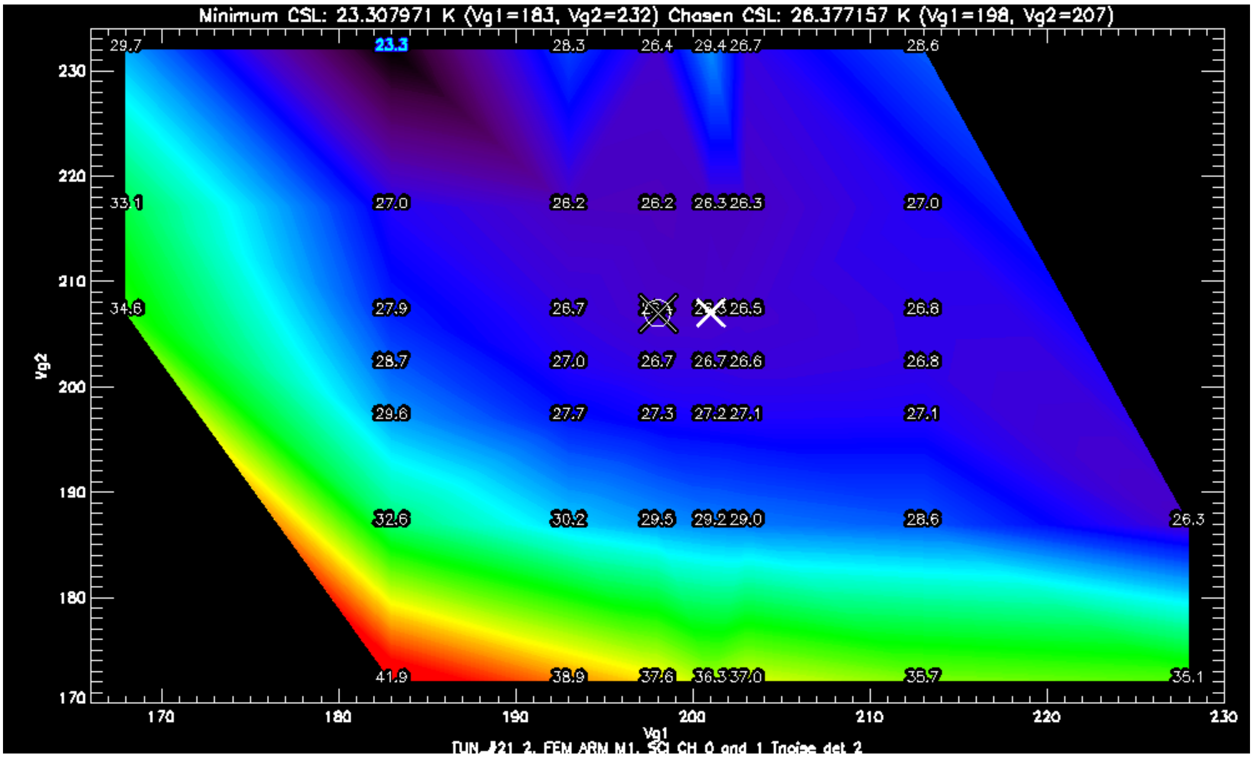

Minimum CSL: 32.054800 K (Vg1=199, Vg2=236) Chosen CSL: 33.083244 K (Vg1=199, Vg2=221)
Vg2
Vg1
190
200
210
220
230
180
TUN_#20 1, FEM ARM S1, SCI CH 2 and 3 [noise det 2

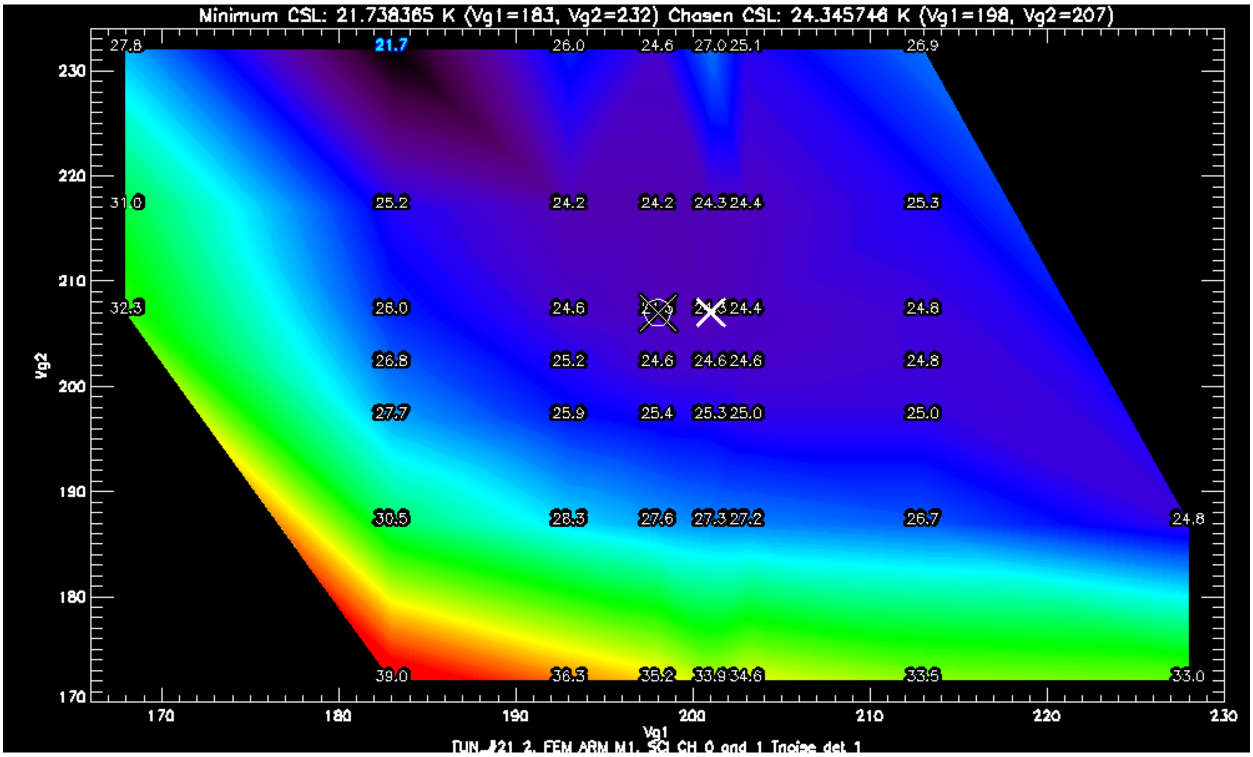

Minimum CSL: 32.175561 K (Vg1=199, Vg2=236) Chosen CSL: 33.225275 K (Vg1=199, Vg2=221)
Vg2
Vg1
190
200
210
220
230
180
TUN_#20 1, FEM ARM S1, SCI CH 2 and 3 [noise det 1

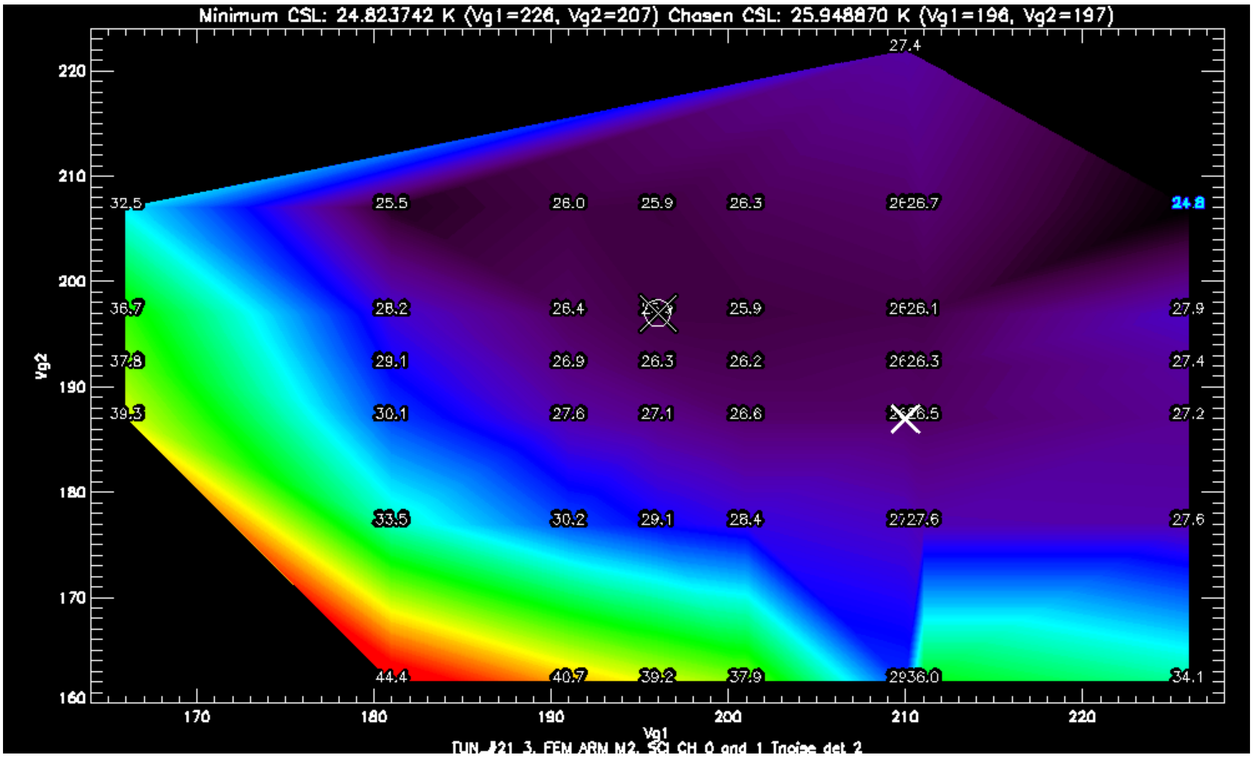

Minimum CSL: 31.552347 K (Vg1=188, Vg2=191) Chosen CSL: 33.236667 K (Vg1=188, Vg2=201)
36.5
39.2
41.1
46.8
57.3
33.7
36.1
37.4
38.6
42.3
46.3
32.9
34.5
35.6
36.5
39.4
44.7
32.8
33.8
34.8
35.6
38.0
43.0
32.6
34.2
36.9
41.3
33.5
31.6
33.6
33.9
35.5
38.8
37.2
37.1
36.8
37.2
39.8
Vg2
230
220
210
200
190
180
180
190
200
210
220
Vg1

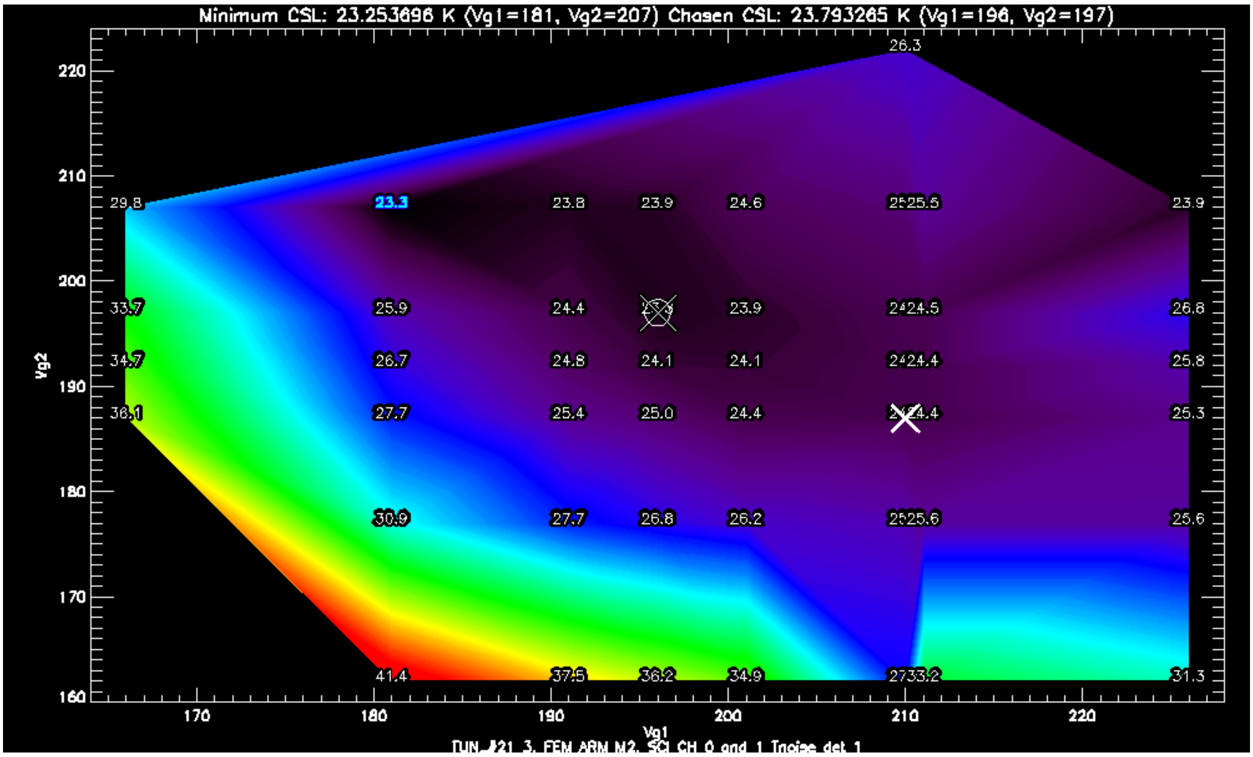

Minimum CSL: 31.973426 K (Vg1=188, Vg2=191) Chosen CSL: 33.547264 K (Vg1=188, Vg2=201)
36.3
38.6
40.6
46.5
58.2
33.7
35.8
37.2
38.3
42.0
45.8
33.2
34.4
35.6
36.4
39.2
44.1
33.1
33.9
34.8
35.6
37.9
42.5
33.2
34.2
37.0
41.1
34.1
32.0
33.8
34.3
35.7
39.0
38.3
37.8
37.8
38.1
40.6
Vg2
230
220
210
200
190
180
180
190
200
210
220
Vg1

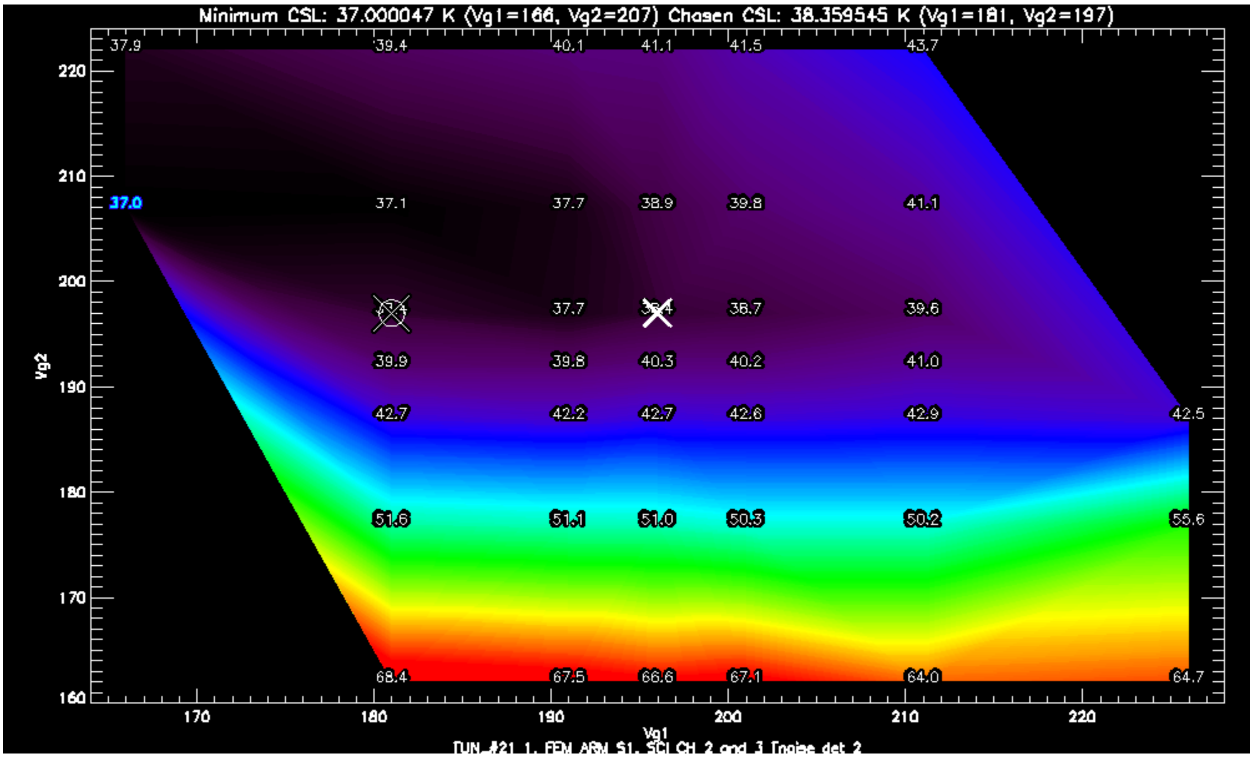
6.1.4 RCA21 Contour Plots

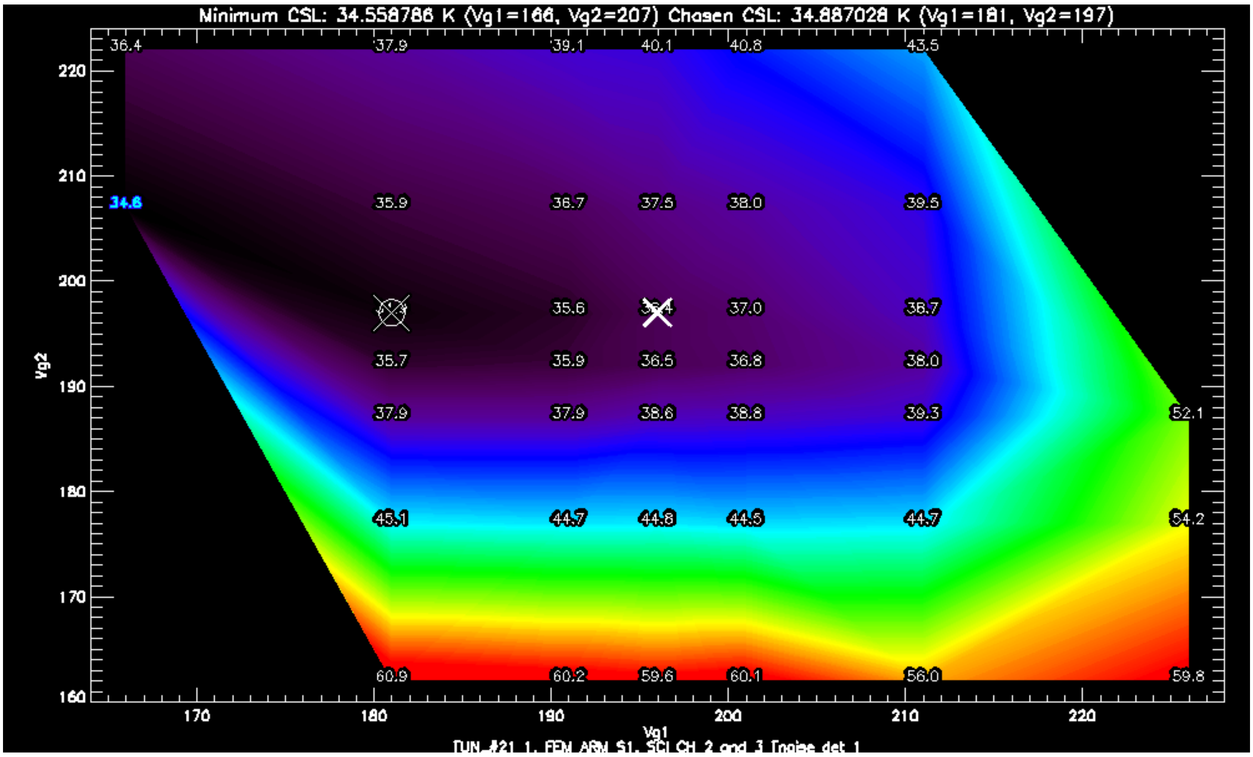


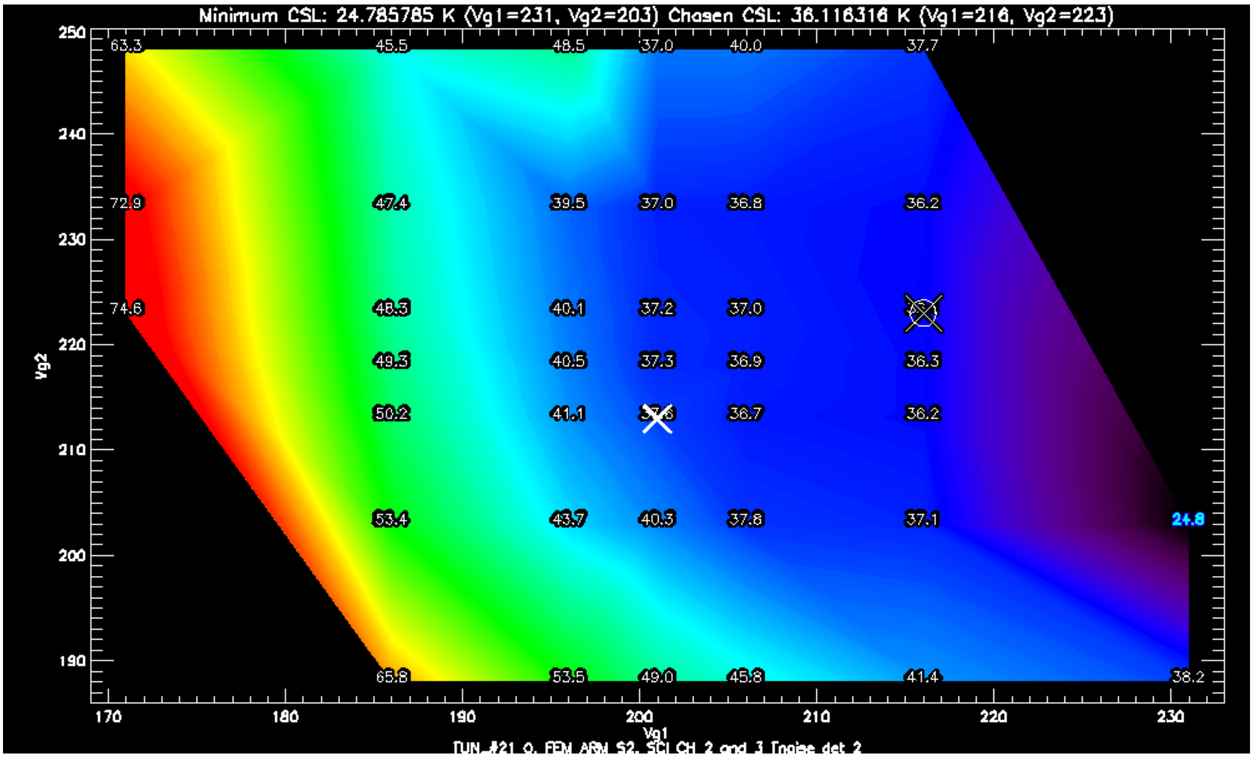


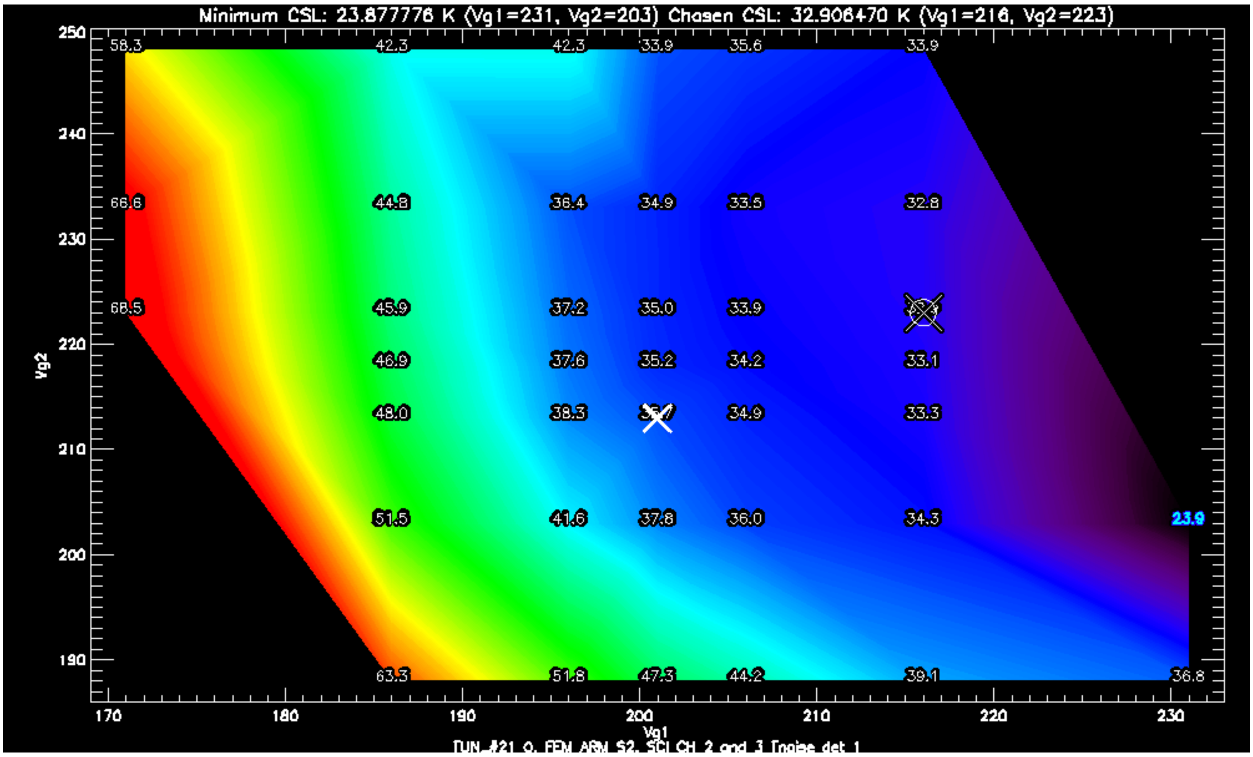

Minimum CSL: 24.823742 K (Vg1=226, Vg2=207) Chosen CSL: 25.948870 K (Vg1=196, Vg2=197)
Vg2
Vg1
TUN_#21_3, FEM ARM M2, SCI CH 0 and 1 Tnoise det 2


Minimum CSL: 23.253696 K (Vg1=181, Vg2=207) Chosen CSL: 23.793265 K (Vg1=196, Vg2=197)
Vg2
Vg1
TUN_#21_3, FEM ARM M2, SCI CH 0 and 1 Tnoise det 1

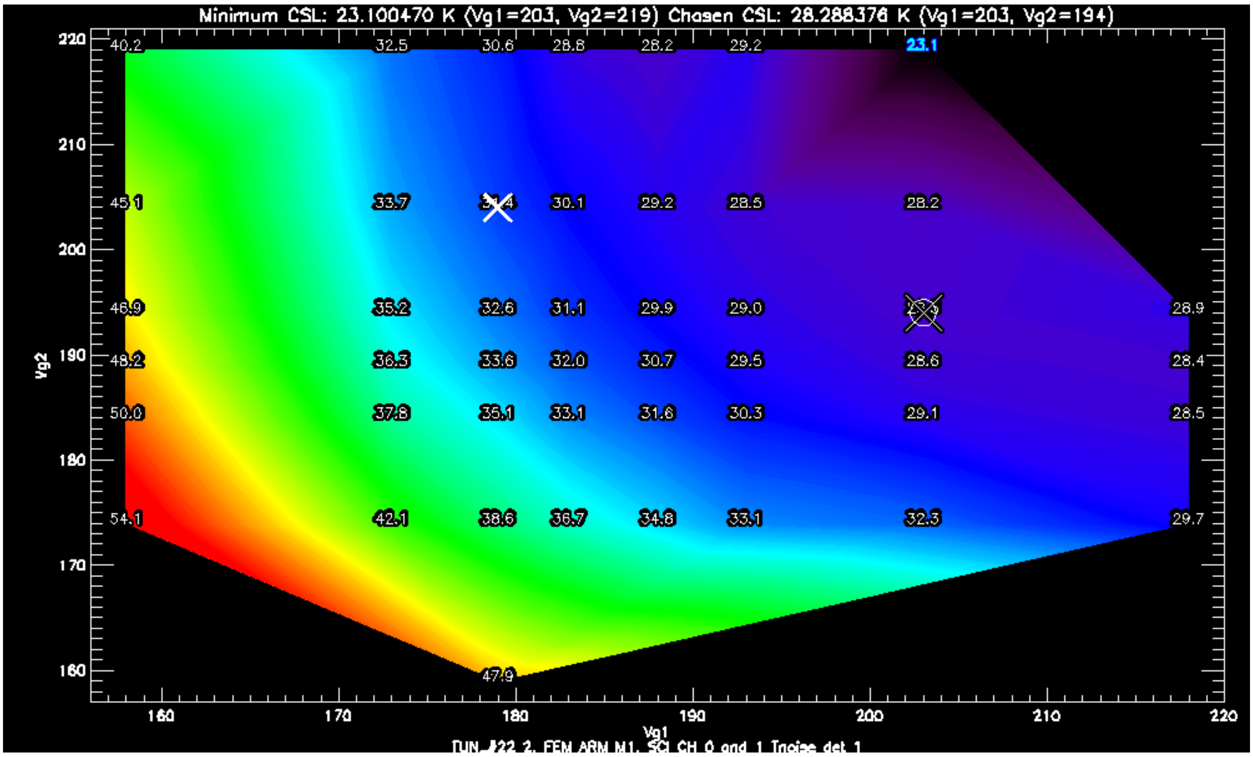

Minimum CSL: 37.000047 K (Vg1=166, Vg2=207) Chosen CSL: 38.359545 K (Vg1=181, Vg2=197)
Vg1
Vg2
TUN_#21_1, FEM ARM S1, SCI CH 2 and 3 [noise det 2

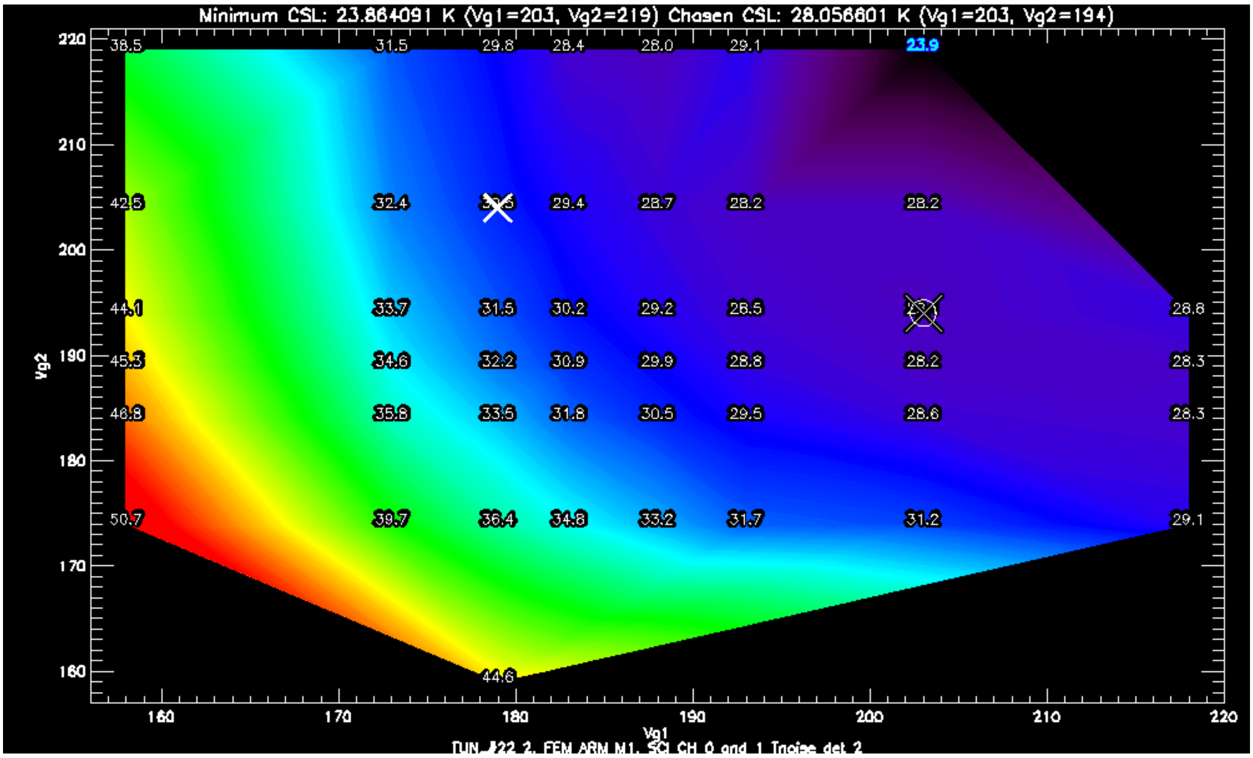

Minimum CSL: 34.558786 K (Vg1=166, Vg2=207) Chosen CSL: 34.887028 K (Vg1=181, Vg2=197)
Vg1
Vg2
TUN_#21_1, FEM ARM S1, SCI CH 2 and 3 [noise det 1

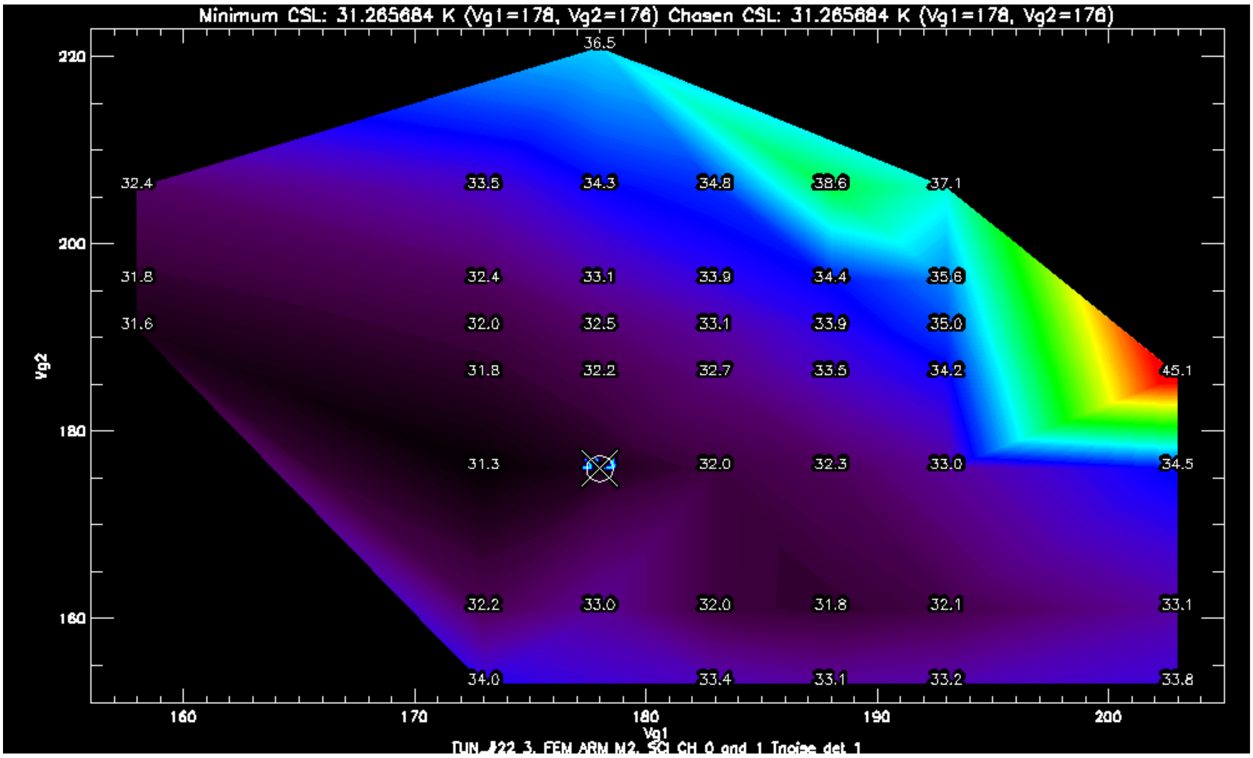

Minimum CSL: 24.785785 K (Vg1=231, Vg2=203) Chosen CSL: 36.116316 K (Vg1=216, Vg2=223)
Vg2
Vg1

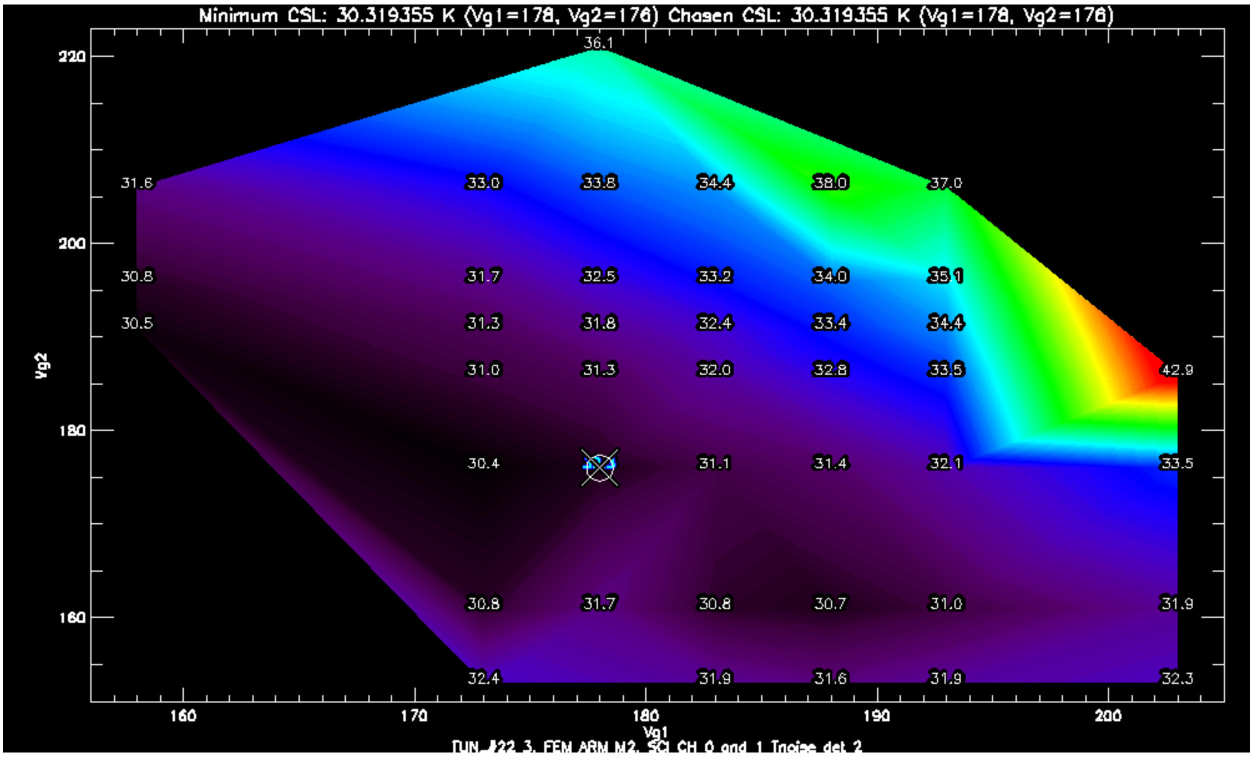

Minimum CSL: 23.877776 K (Vg1=231, Vg2=203) Chosen CSL: 32.906470 K (Vg1=216, Vg2=223)
Vg2
Vg1

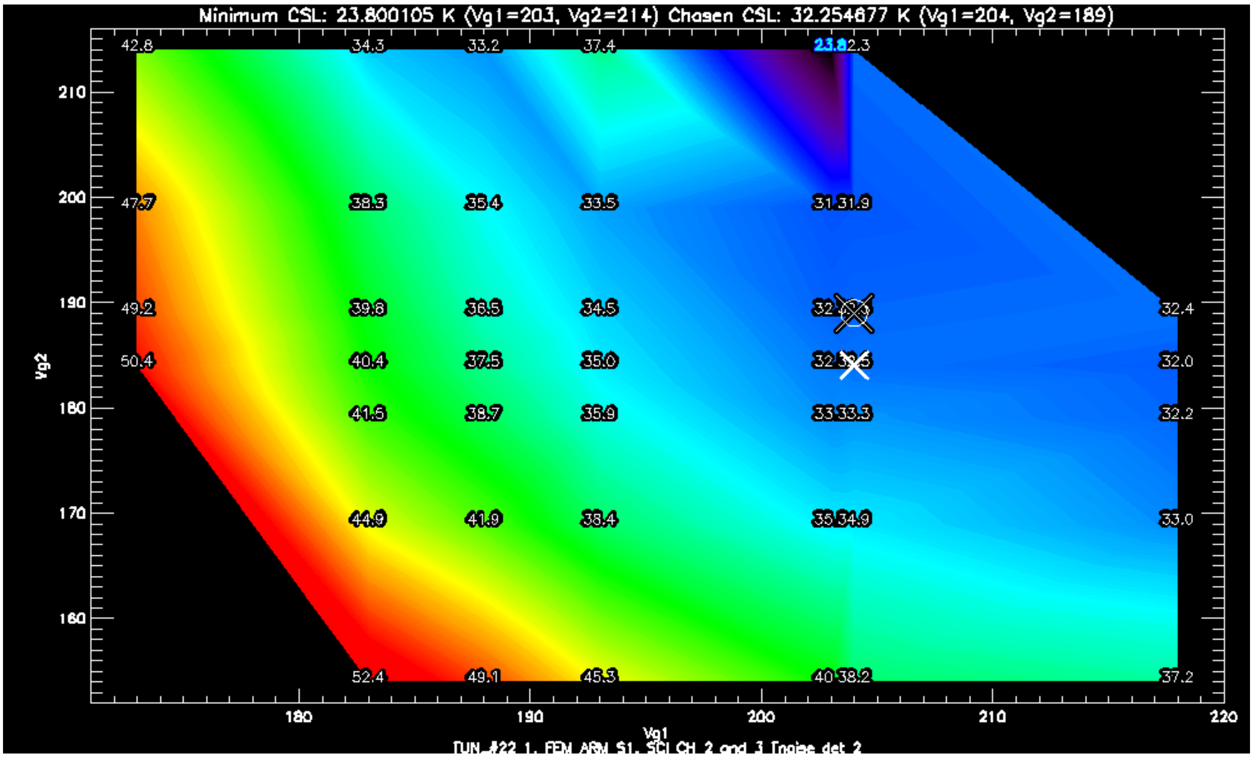
6.1.5 RCA22 Contour Plots

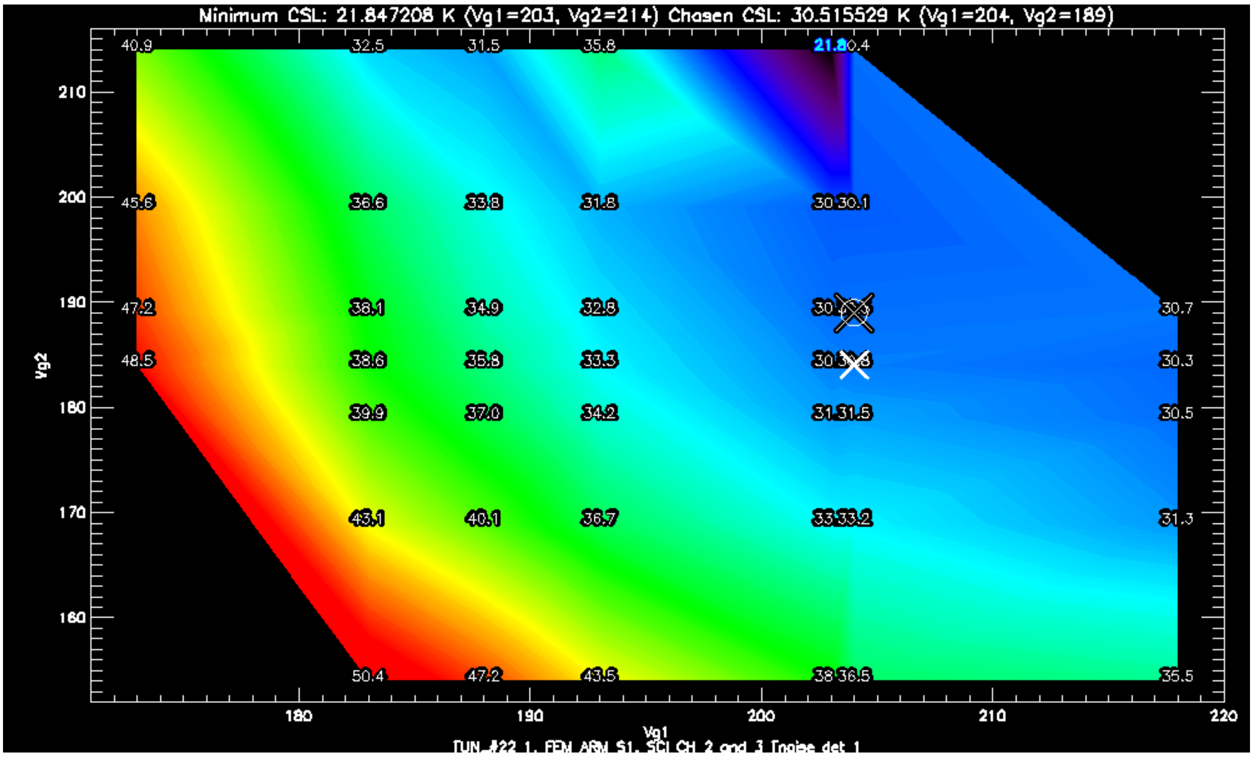


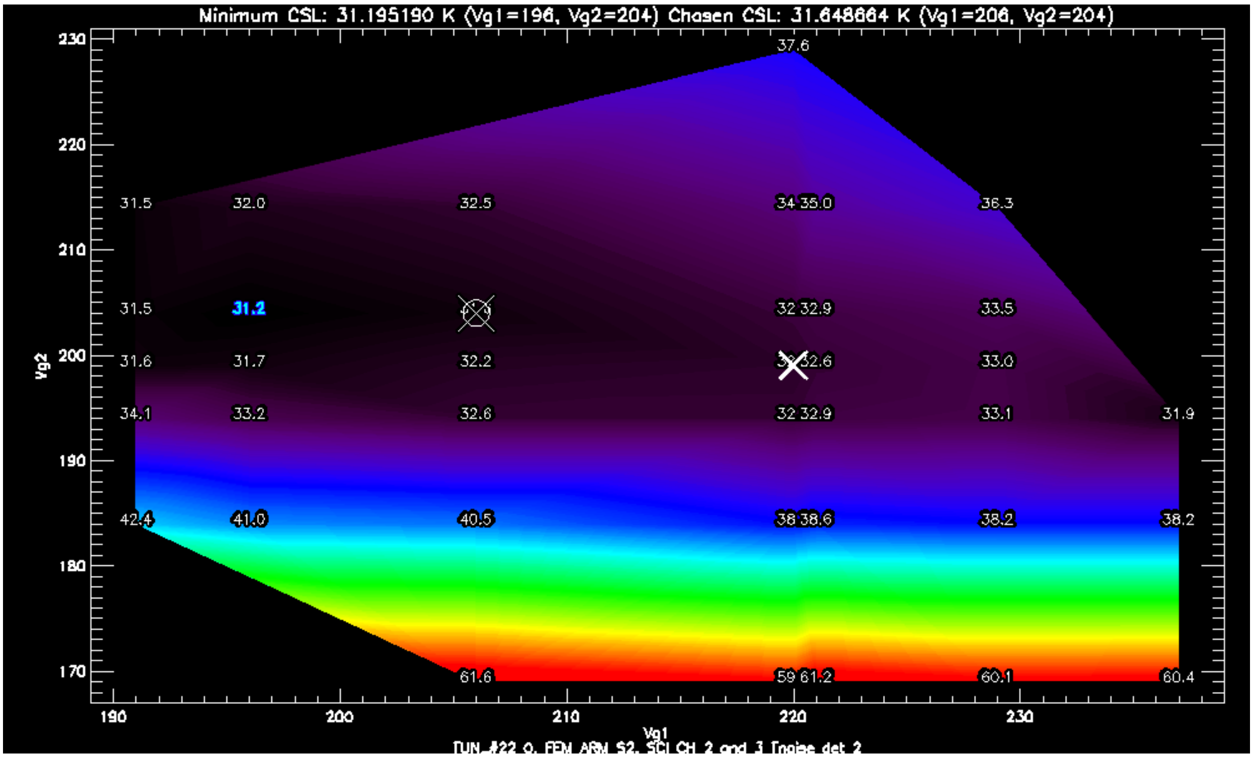


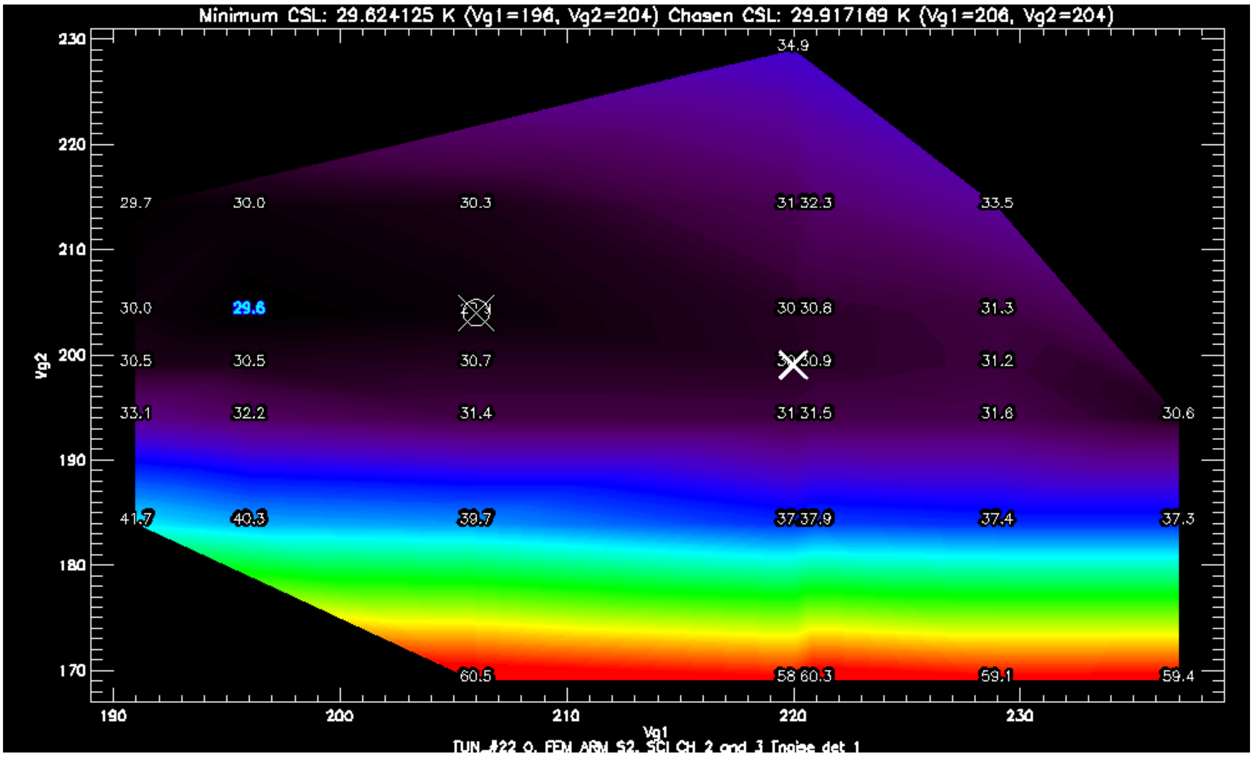

Minimum CSL: 31.265684 K (Vg1=178, Vg2=176) Chosen CSL: 31.265684 K (Vg1=178, Vg2=176)
Vg2
Vg1
TUN_#22_3, FEM ARM M2, SCI CH 0 and 1 Tnoise det 1


Minimum CSL: 30.319355 K (Vg1=178, Vg2=176) Chosen CSL: 30.319355 K (Vg1=178, Vg2=176)
Vg2
Vg1
TUN_#22_3, FEM ARM M2, SCI CH 0 and 1 Tnoise det 2

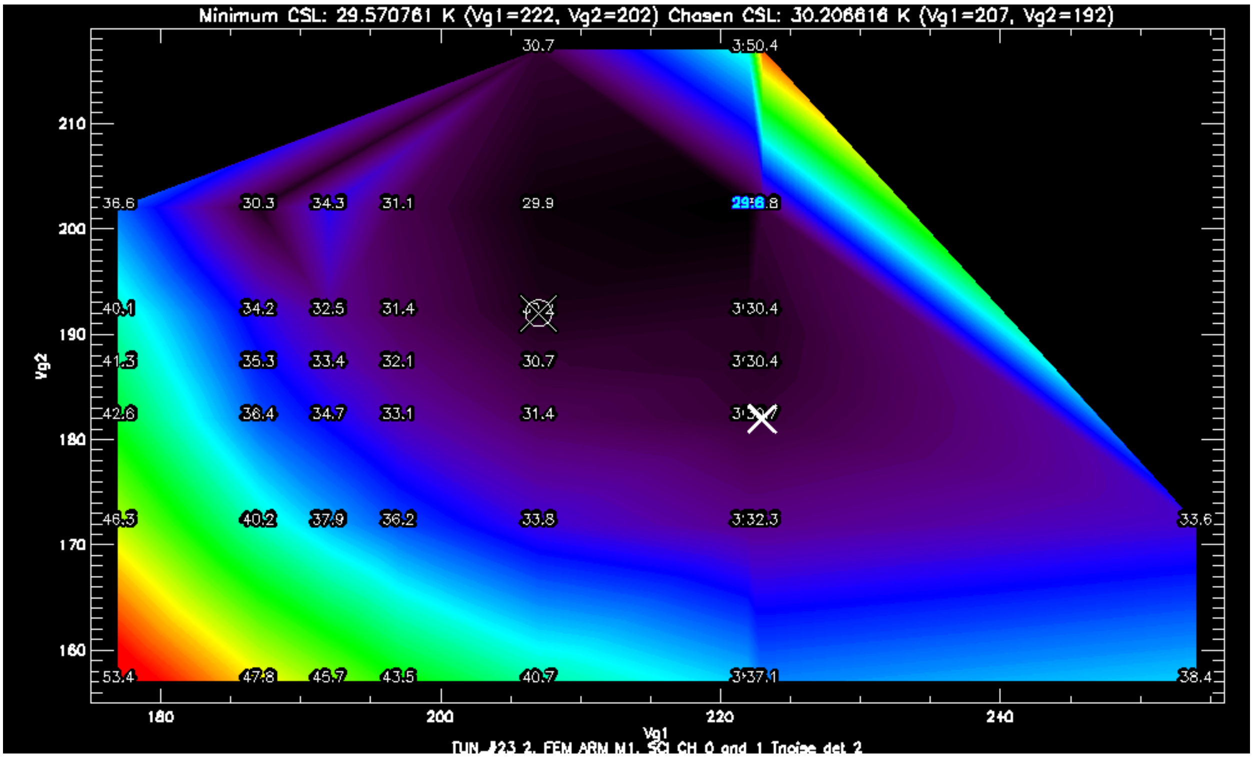

Minimum CSL: 23.800105 K (Vg1=203, Vg2=214) Chosen CSL: 32.254677 K (Vg1=204, Vg2=189)
Vg2
Vg1
TUN_#22 1. FEM ARM S1. SCI CH 2 and 3 [noise det 2

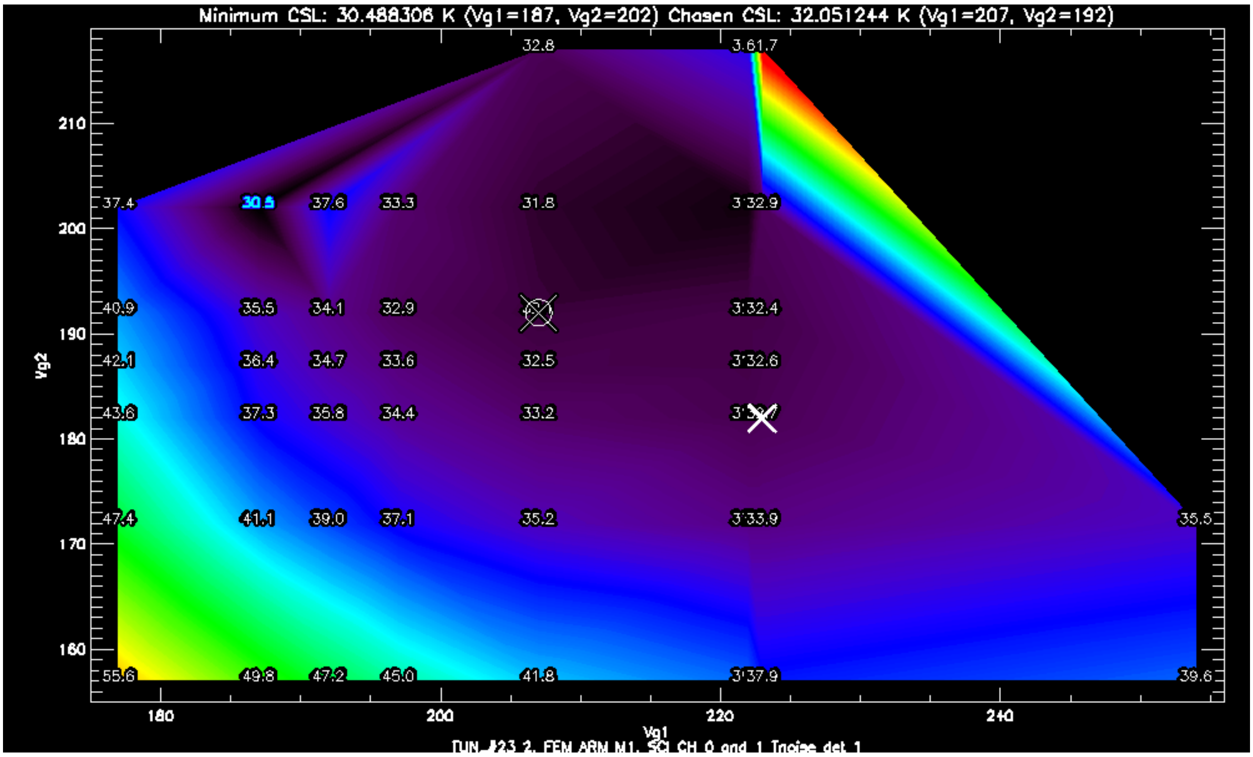

Minimum CSL: 21.847208 K (Vg1=203, Vg2=214) Chosen CSL: 30.515529 K (Vg1=204, Vg2=189)
Vg2
Vg1
TUN_#22 1. FEM ARM S1. SCI CH 2 and 3 [noise det 1

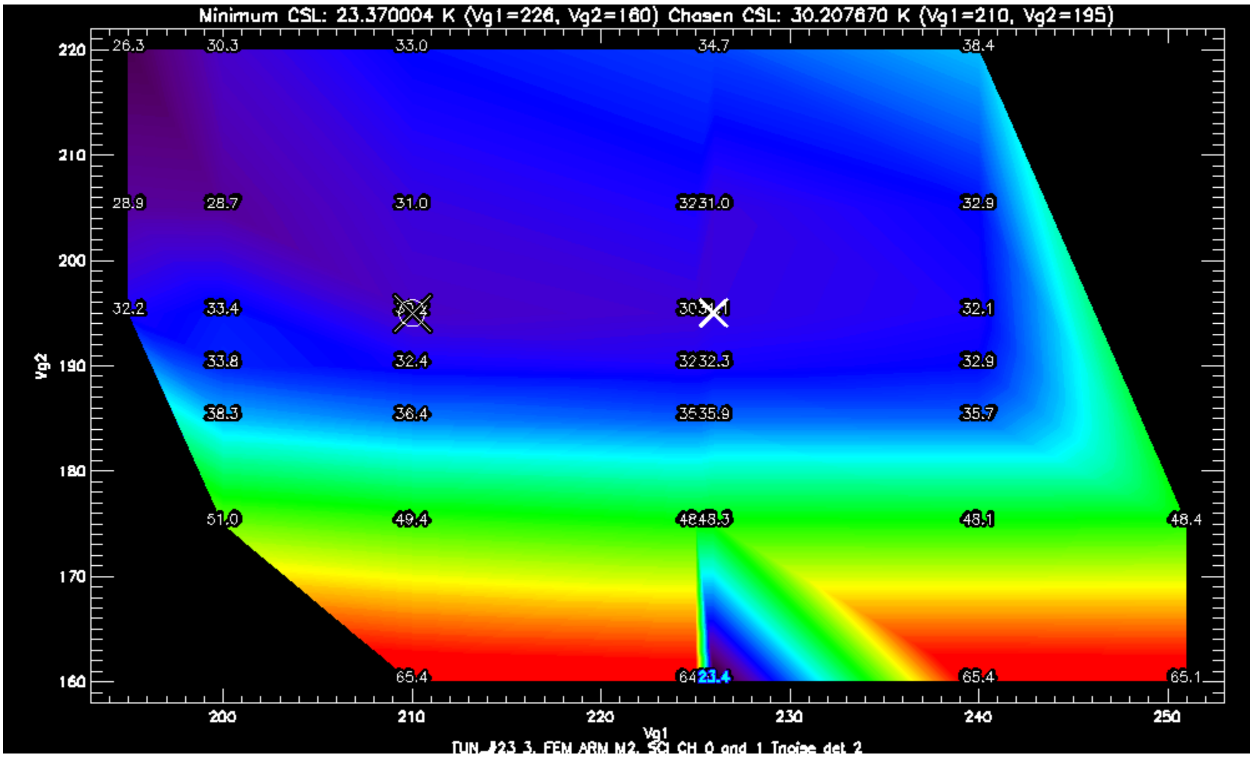

Minimum CSL: 31.195190 K (Vg1=196, Vg2=204) Chosen CSL: 31.648664 K (Vg1=206, Vg2=204)
Vg2
Vg1
TUN_#22 0. FEM ARM S2. SCI CH 2 and 3 Tnoise det 2

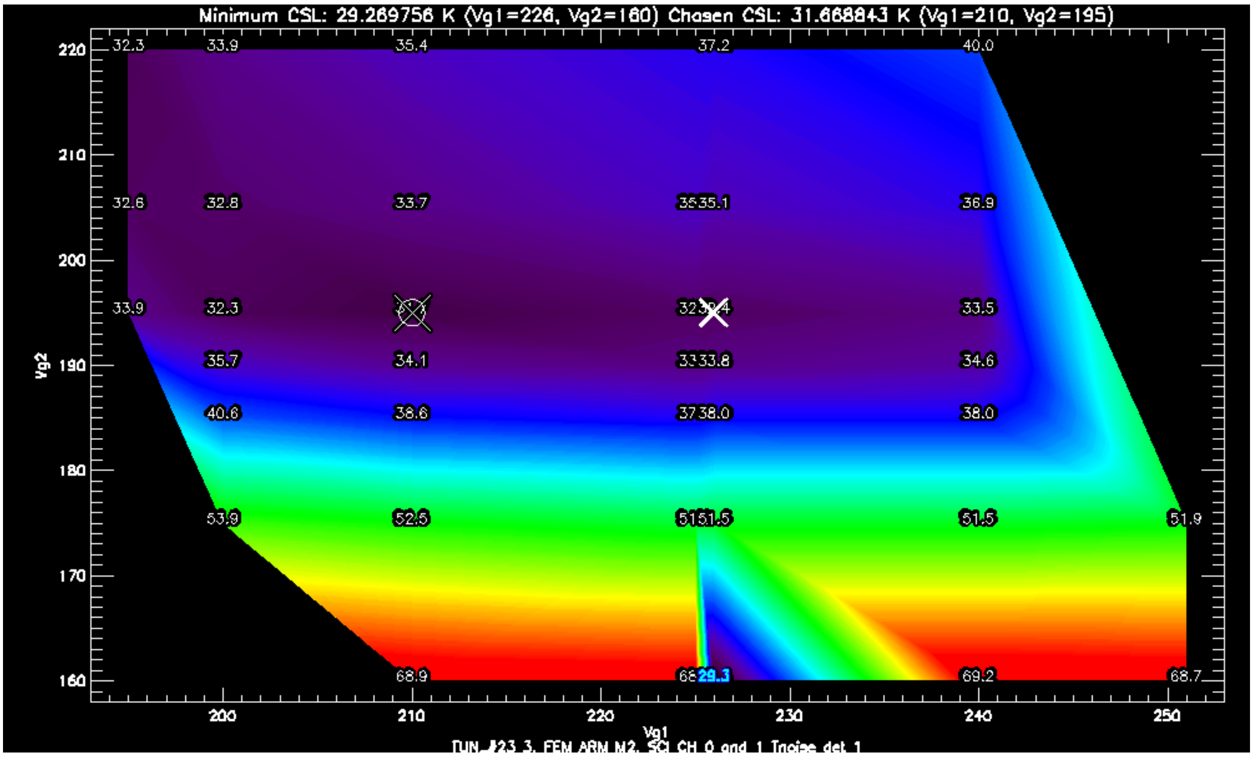

Minimum CSL: 29.624125 K (Vg1=196, Vg2=204) Chosen CSL: 29.917169 K (Vg1=206, Vg2=204)
Vg2
Vg1
TUN_#22 0. FEM ARM S2. SCI CH 2 and 3 Tnoise det 1

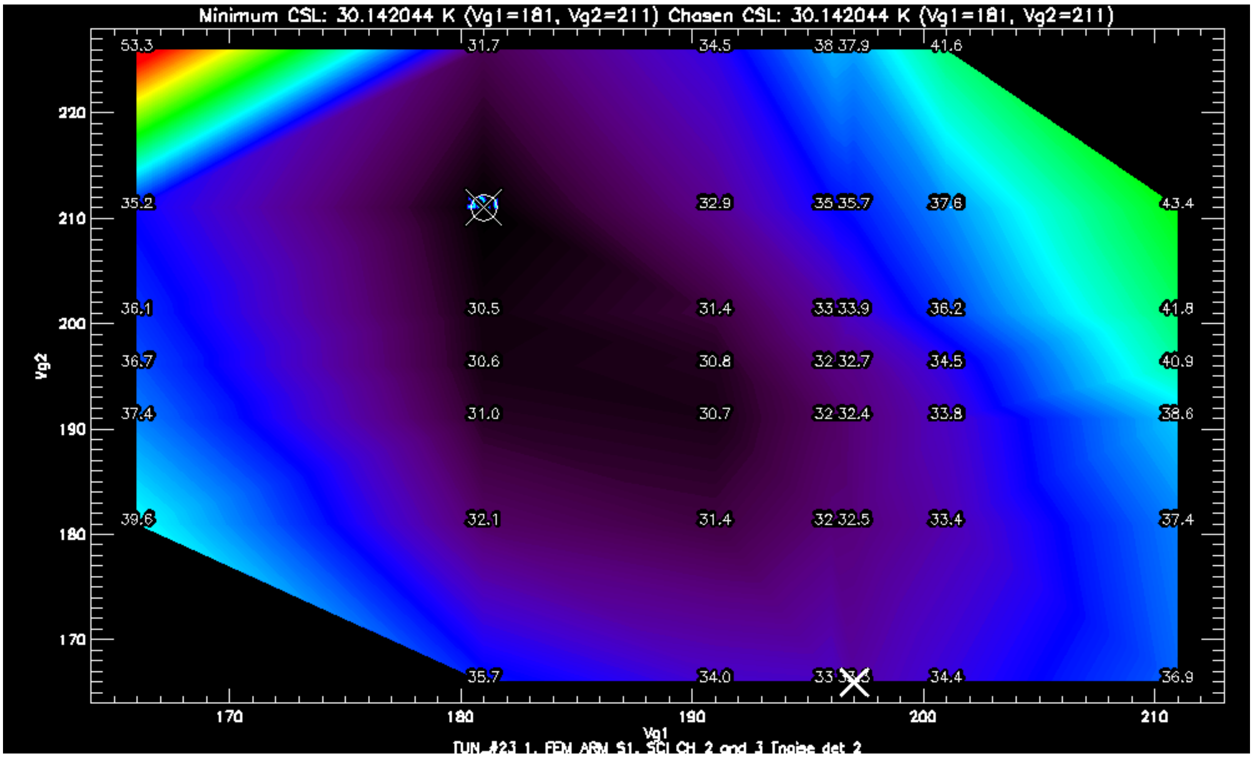
6.1.6 RCA23 Contour Plots

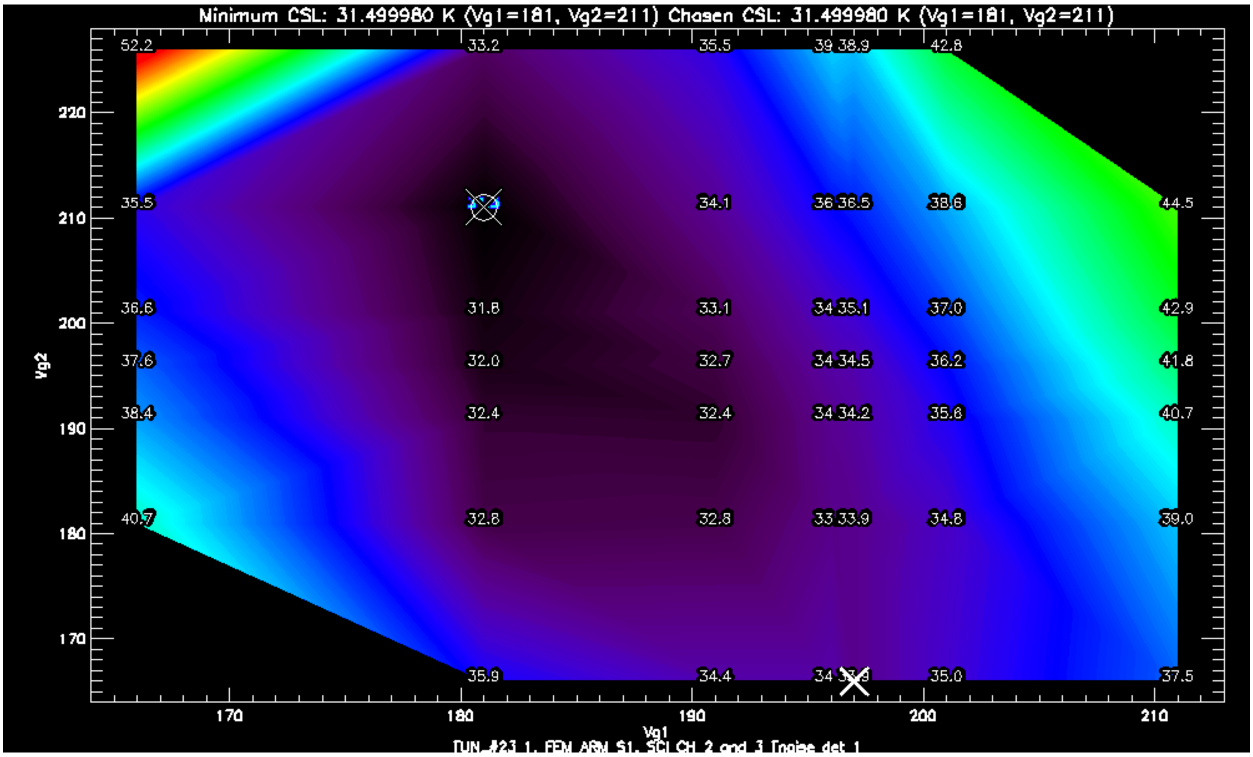


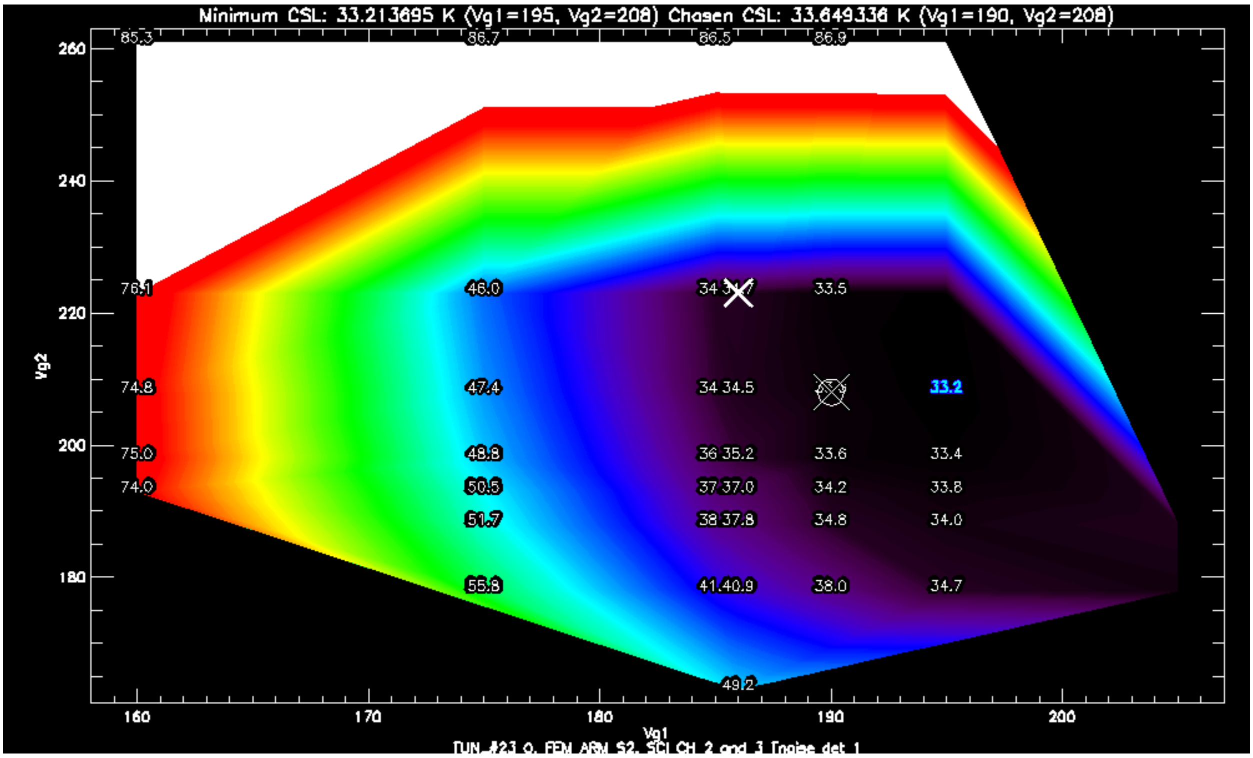


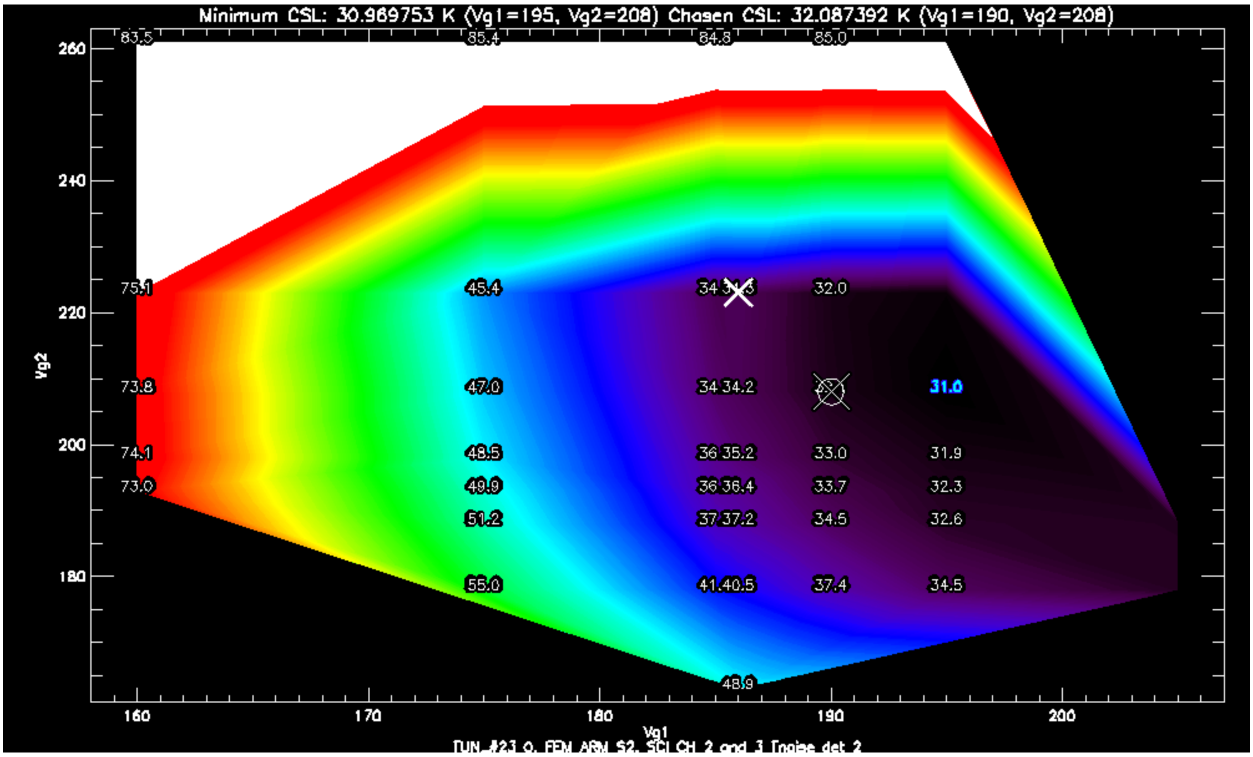

Minimum CSL: 23.370004 K (Vg1=226, Vg2=160) Chosen CSL: 30.207670 K (Vg1=210, Vg2=195)
Vg2
Vg1
TUN_#23 3, FEM ARM M2, SCI CH 0 and 1 Tnoise det 2


Minimum CSL: 29.269756 K (Vg1=226, Vg2=160) Chosen CSL: 31.668843 K (Vg1=210, Vg2=195)
Vg2
Vg1
TUN_#23 3, FEM ARM M2, SCI CH 0 and 1 Tnoise det 1

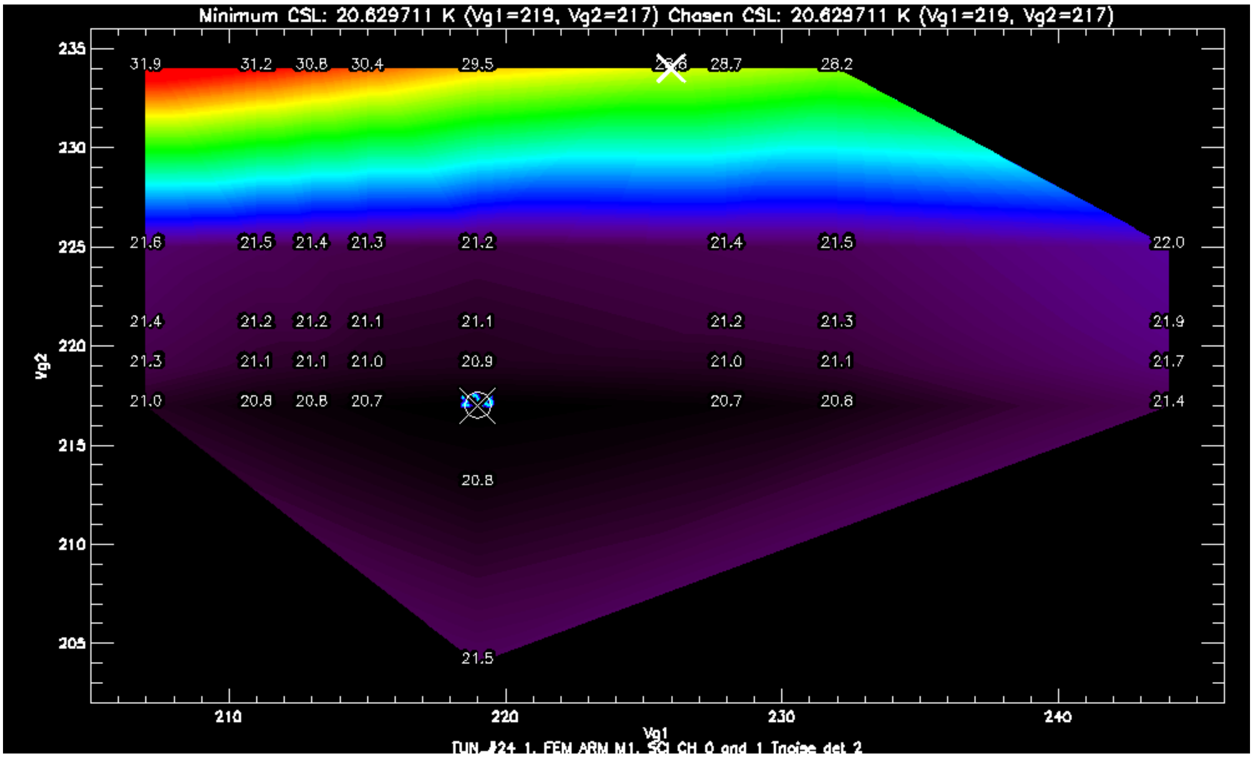

Minimum CSL: 30.142044 K (Vg1=181, Vg2=211) Chosen CSL: 30.142044 K (Vg1=181, Vg2=211)
53.3
31.7
34.5
38 37.9
41.6
35.2
32.9
35 35.7
37.6
43.4
36.1
30.5
31.4
33 33.9
36.2
41.8
36.7
30.6
30.8
32 32.7
34.5
40.9
37.4
31.0
30.7
32 32.4
33.8
38.6
39.6
32.1
31.4
32 32.5
33.4
37.4
35.7
34.0
33
34.4
36.9
220
210
200
190
180
170
Vg2
170
180
190
200
210
Vg1
TUN_#23 1, FEM ARM S1, SCI CH 2 and 3 [noise det 2

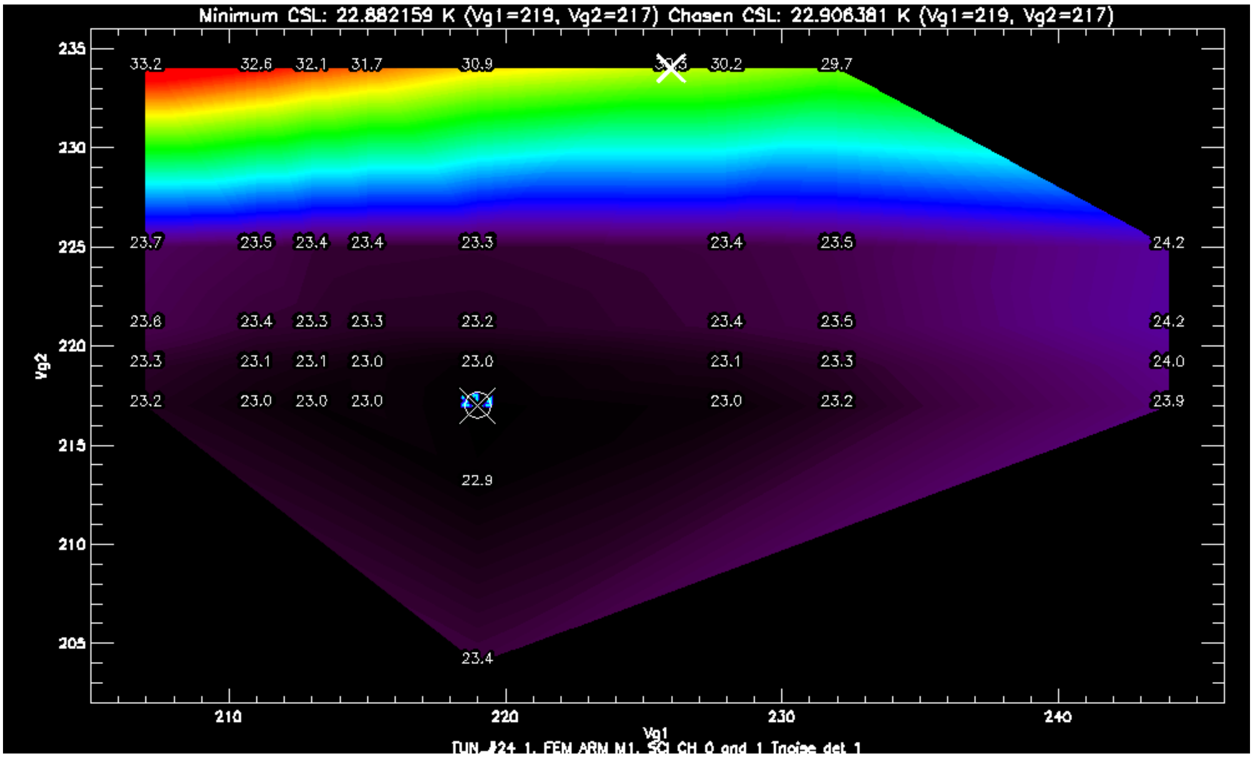

Minimum CSL: 31.499980 K (Vg1=181, Vg2=211) Chosen CSL: 31.499980 K (Vg1=181, Vg2=211)
52.2
33.2
35.5
39 38.9
42.8
35.5
34.1
36 36.5
38.6
44.5
36.6
31.8
33.1
34 35.1
37.0
42.9
37.6
32.0
32.7
34 34.5
36.2
41.8
38.4
32.4
32.4
34 34.2
35.6
40.7
40.7
32.8
32.8
33 33.9
34.8
39.0
35.9
34.4
34
35.0
37.5
220
210
200
190
180
170
Vg2
170
180
190
200
210
Vg1
TUN_#23 1, FEM ARM S1, SCI CH 2 and 3 [noise det 1

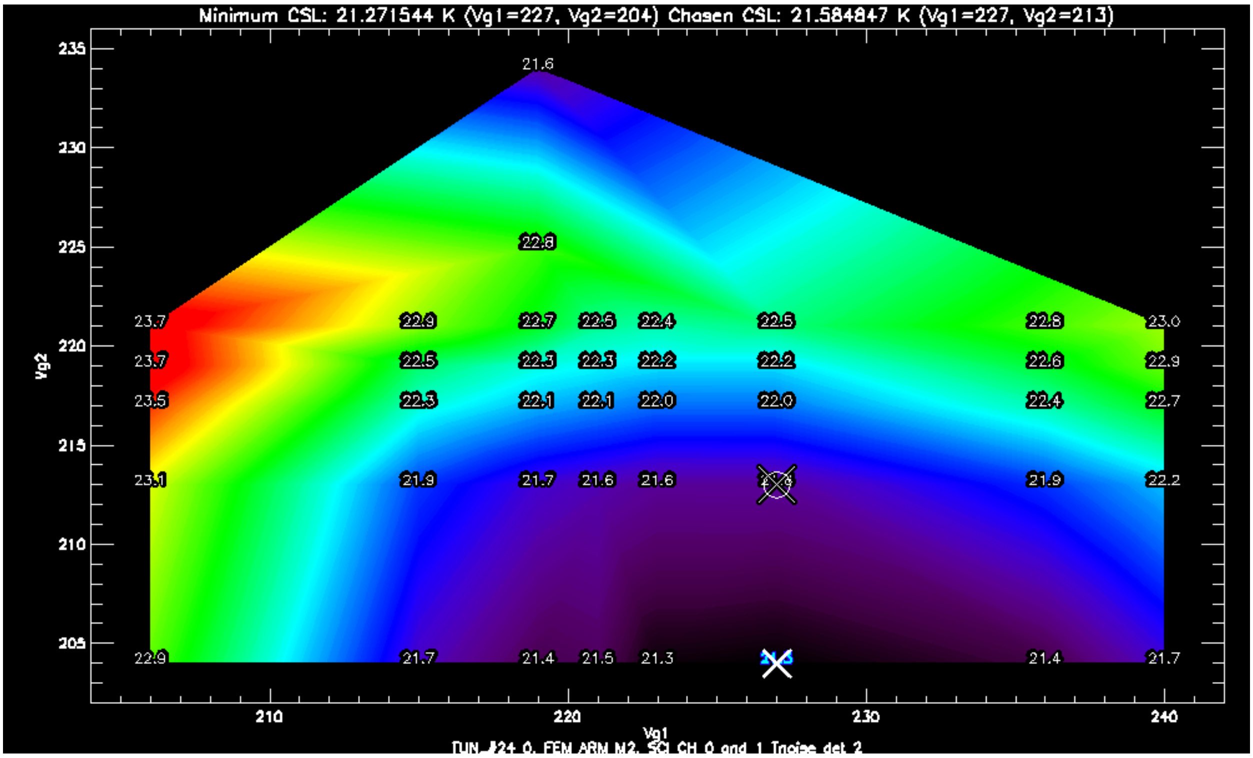

Minimum CSL: 33.213695 K (Vg1=195, Vg2=208) Chosen CSL: 33.649336 K (Vg1=190, Vg2=208)
85.3
86.7
86.5
86.9
76.1
46.0
33.5
74.8
47.4
34 34.5
33.2
75.0
48.8
36 35.2
33.6
33.4
74.0
50.5
37 37.0
34.2
33.8
51.7
38 37.8
34.8
34.0
55.8
41 40.9
38.0
34.7
49.2
260
240
220
200
180
Vg2
160
170
180
190
200
Vg1

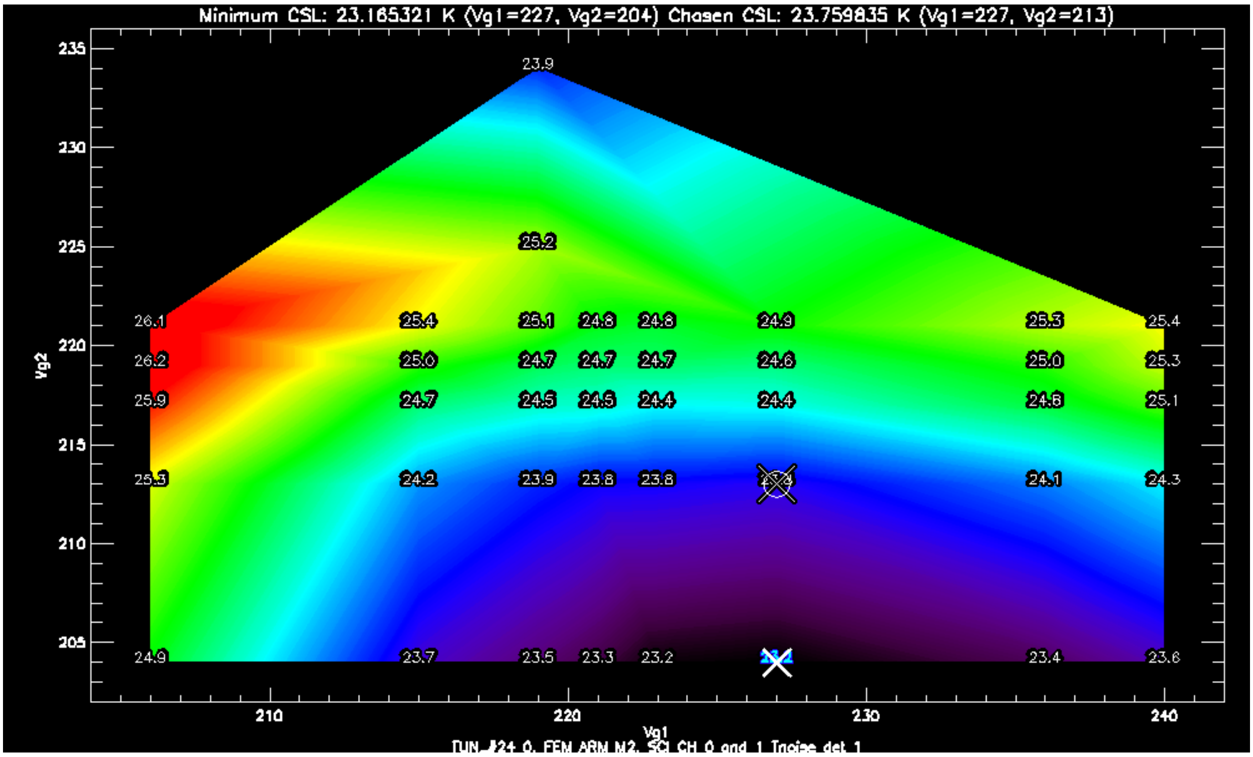

Minimum CSL: 30.969753 K (Vg1=195, Vg2=208) Chosen CSL: 32.087392 K (Vg1=190, Vg2=208)
83.5
85.4
84.8
85.0
75.1
45.4
32.0
73.8
47.0
34 34.2
31.0
74.1
48.5
36 35.2
33.0
31.9
73.0
49.9
36 36.4
33.7
32.3
51.2
37 37.2
34.5
32.6
55.0
41 40.5
37.4
34.5
48.9
260
240
220
200
180
Vg2
160
170
180
190
200
Vg1

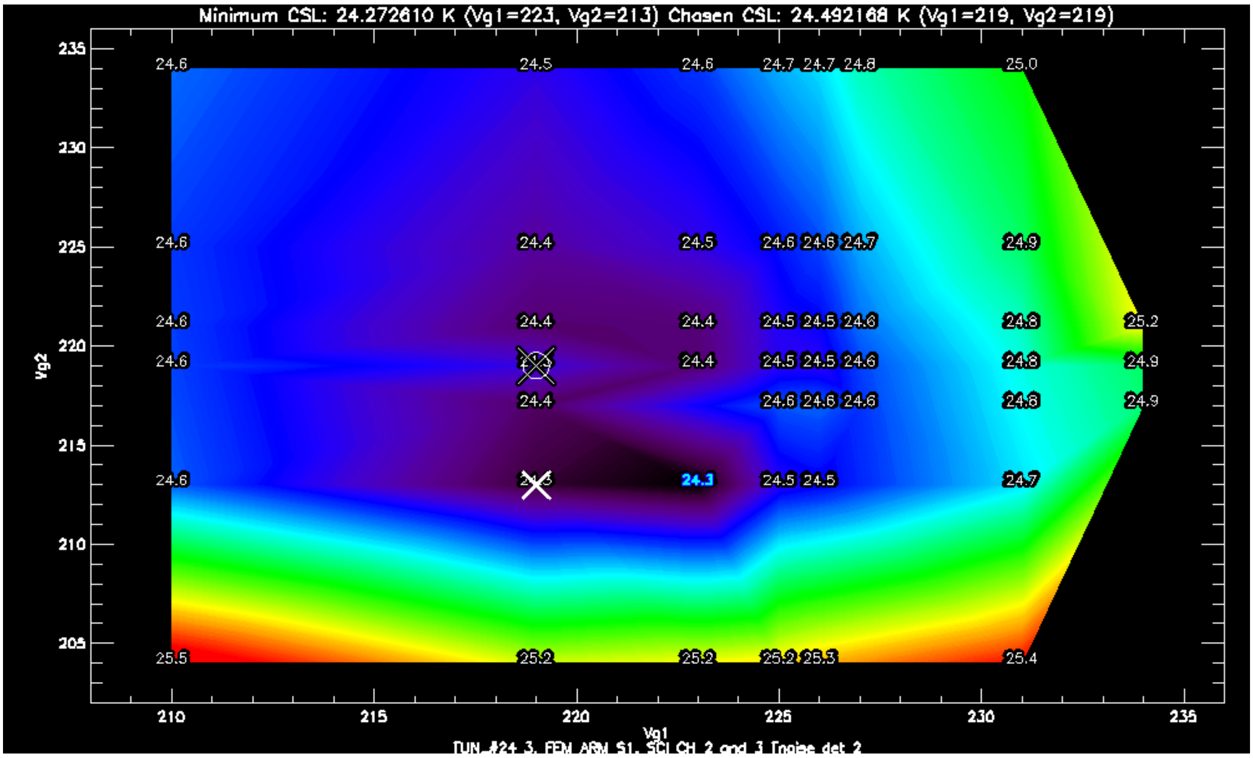
6.1.7 RCA24 Contour Plots

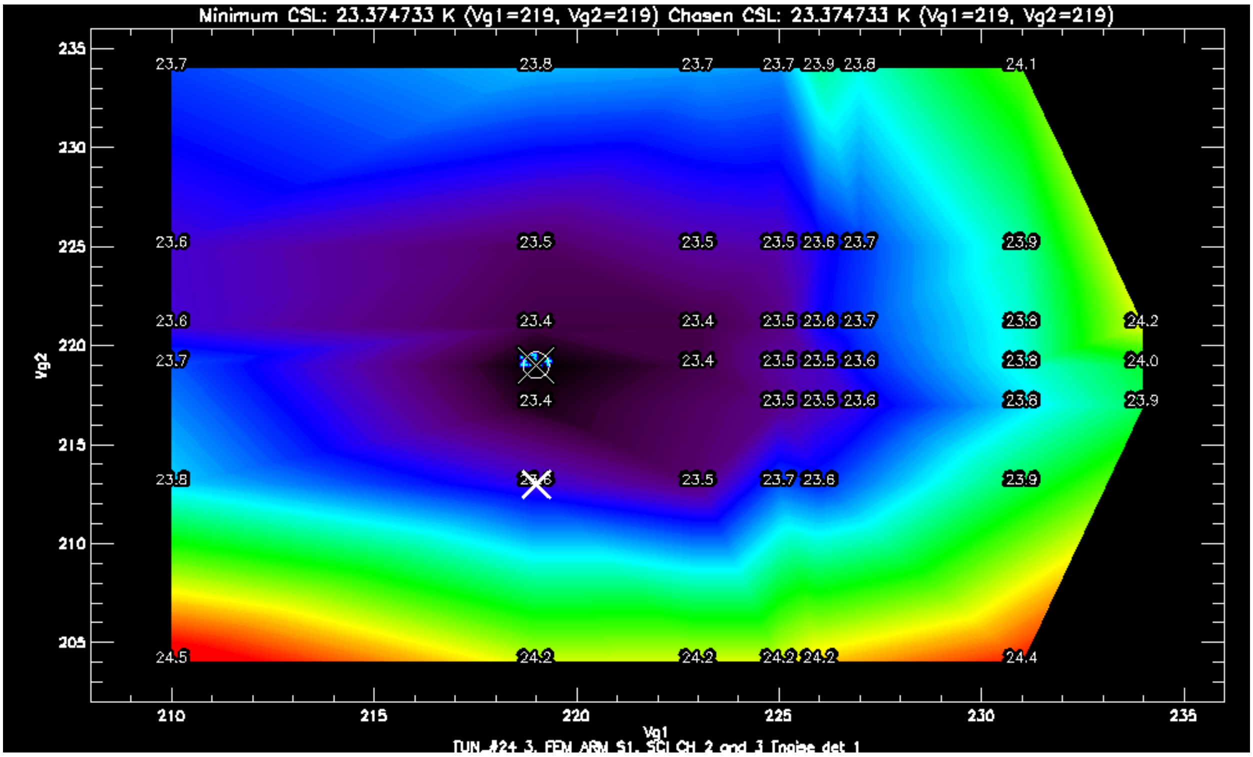


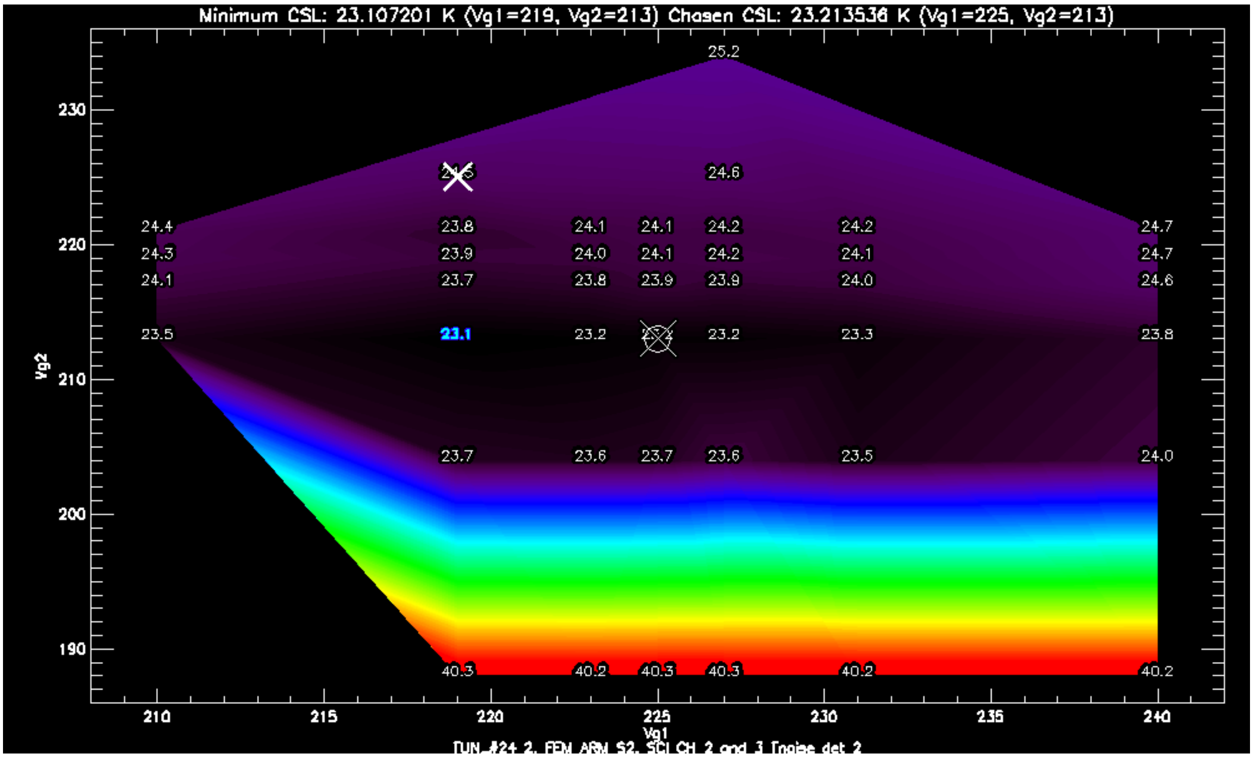


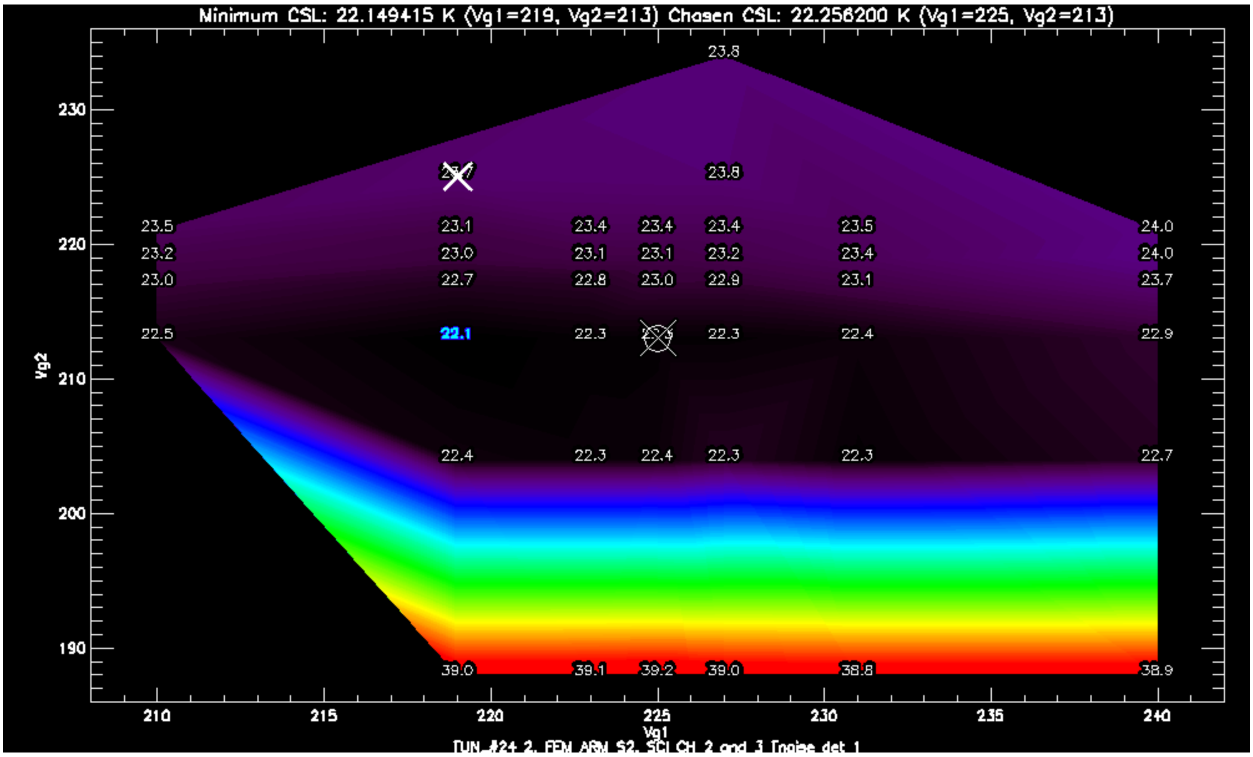

Minimum CSL: 21.271544 K (Vg1=227, Vg2=204) Chosen CSL: 21.584847 K (Vg1=227, Vg2=213)
Vg2
Vg1
235
230
225
220
215
210
205
210
220
230
240
21.6
22.8
23.7 22.9 22.7 22.5 22.4 22.5 22.8 23.0
23.7 22.5 22.3 22.3 22.2 22.2 22.6 22.9
23.5 22.3 22.1 22.1 22.0 22.0 22.4 22.7
23.1 21.9 21.7 21.6 21.6 21.9 22.2
22.9 21.7 21.4 21.5 21.3 21.4 21.7


Minimum CSL: 23.165321 K (Vg1=227, Vg2=204) Chosen CSL: 23.759835 K (Vg1=227, Vg2=213)
Vg2
Vg1
235
230
225
220
215
210
205
210
220
230
240
23.9
25.2
26.1 25.4 25.1 24.8 24.8 24.9 25.3 25.4
26.2 25.0 24.7 24.7 24.7 24.6 25.0 25.3
25.9 24.7 24.5 24.5 24.4 24.4 24.8 25.1
25.3 24.2 23.9 23.8 23.8 24.1 24.3
24.9 23.7 23.5 23.3 23.2 23.4 23.6

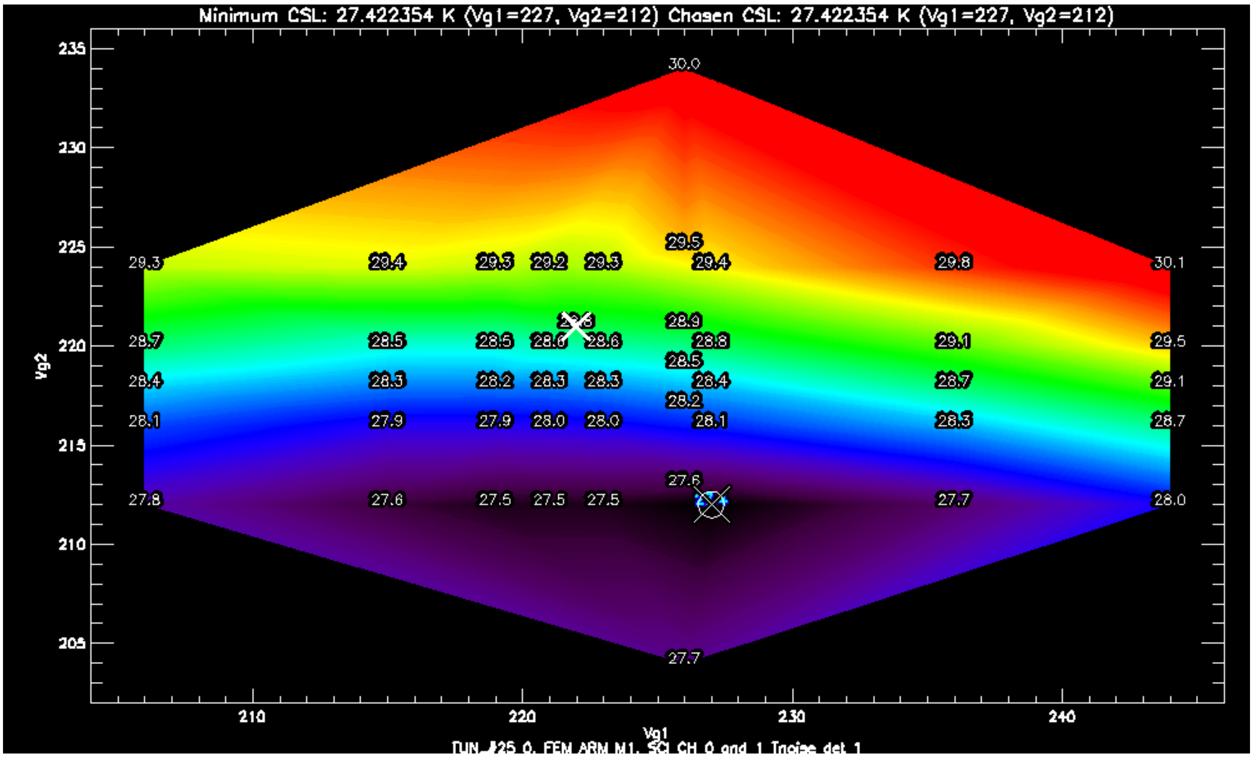

Minimum CSL: 24.272610 K (Vg1=223, Vg2=213) Chosen CSL: 24.492168 K (Vg1=219, Vg2=219)
Vg2
Vg1
TUN_#24 3. FEM ARM S1. SCI CH 2 and 3 [noise det 2

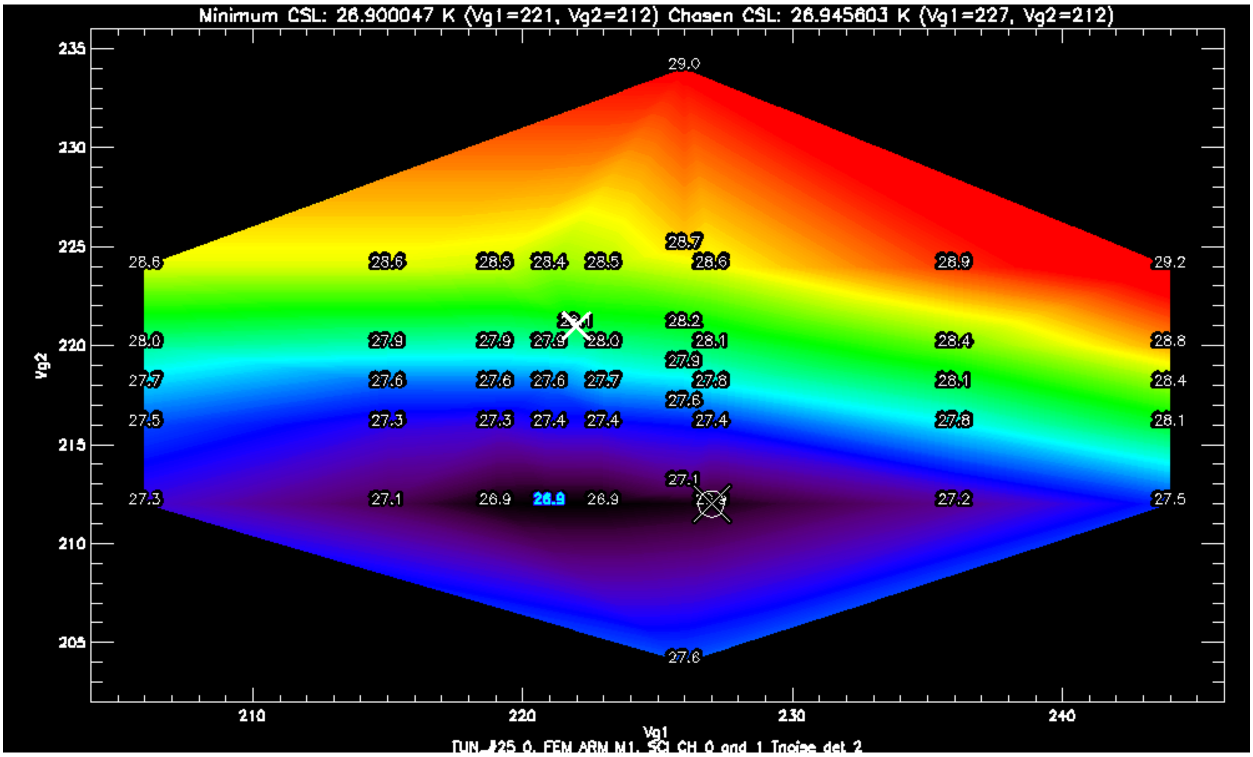

Minimum CSL: 23.374733 K (Vg1=219, Vg2=219) Chosen CSL: 23.374733 K (Vg1=219, Vg2=219)
Vg2
Vg1
TUN_#24 3. FEM ARM S1. SCI CH 2 and 3 [noise det 1

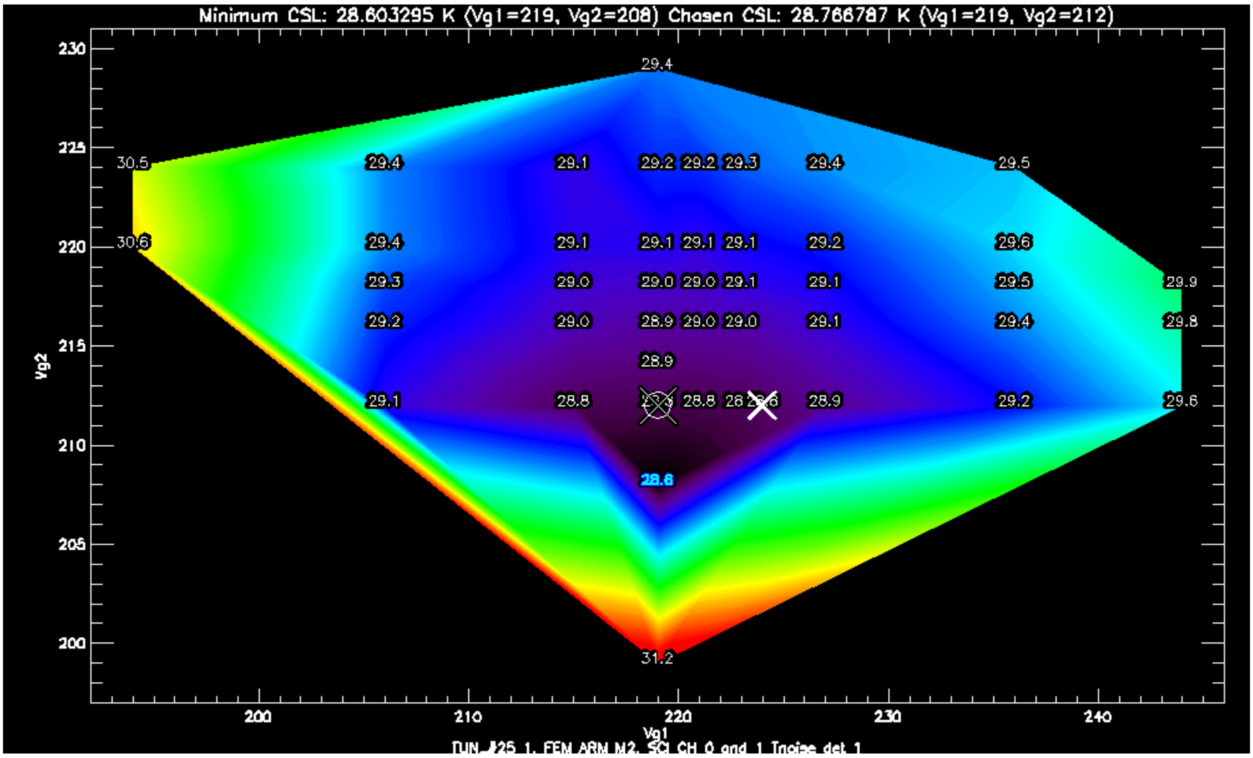

Minimum CSL: 23.107201 K (Vg1=219, Vg2=213) Chosen CSL: 23.213536 K (Vg1=225, Vg2=213)
Vg2
Vg1

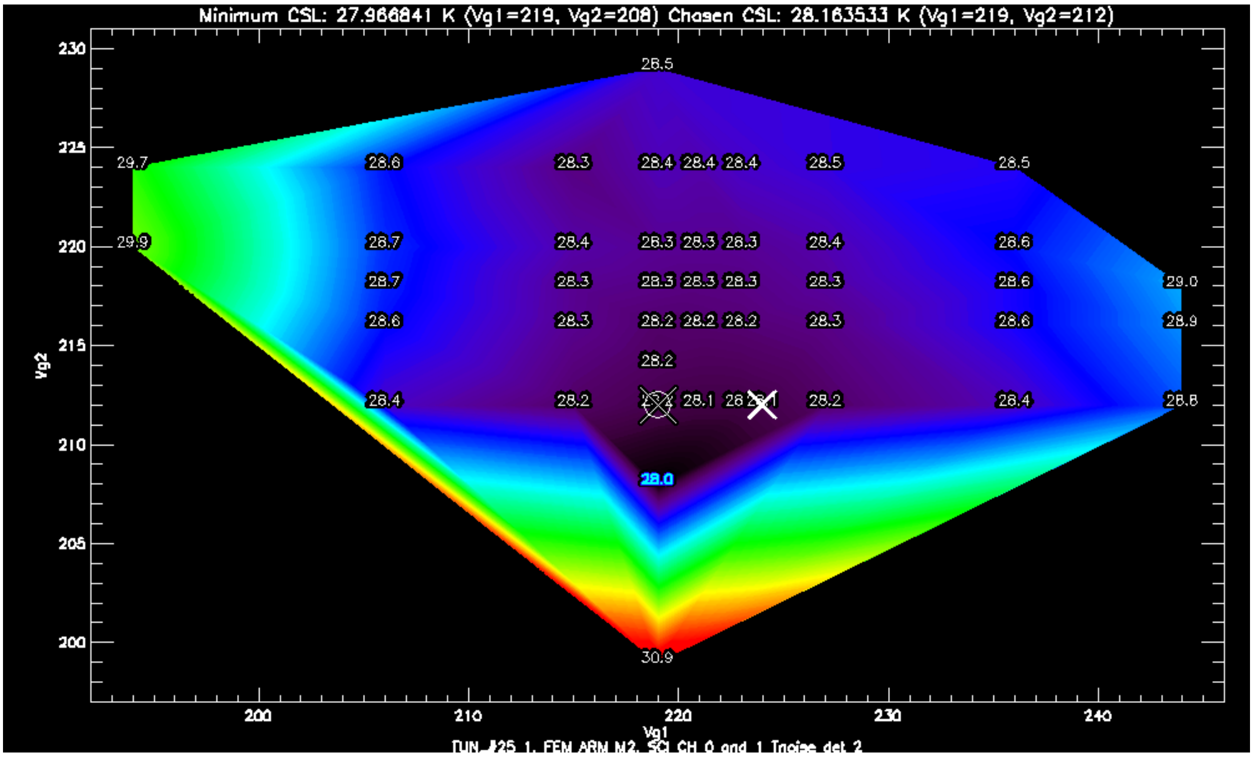

Minimum CSL: 22.149415 K (Vg1=219, Vg2=213) Chosen CSL: 22.256200 K (Vg1=225, Vg2=213)
Vg2
Vg1

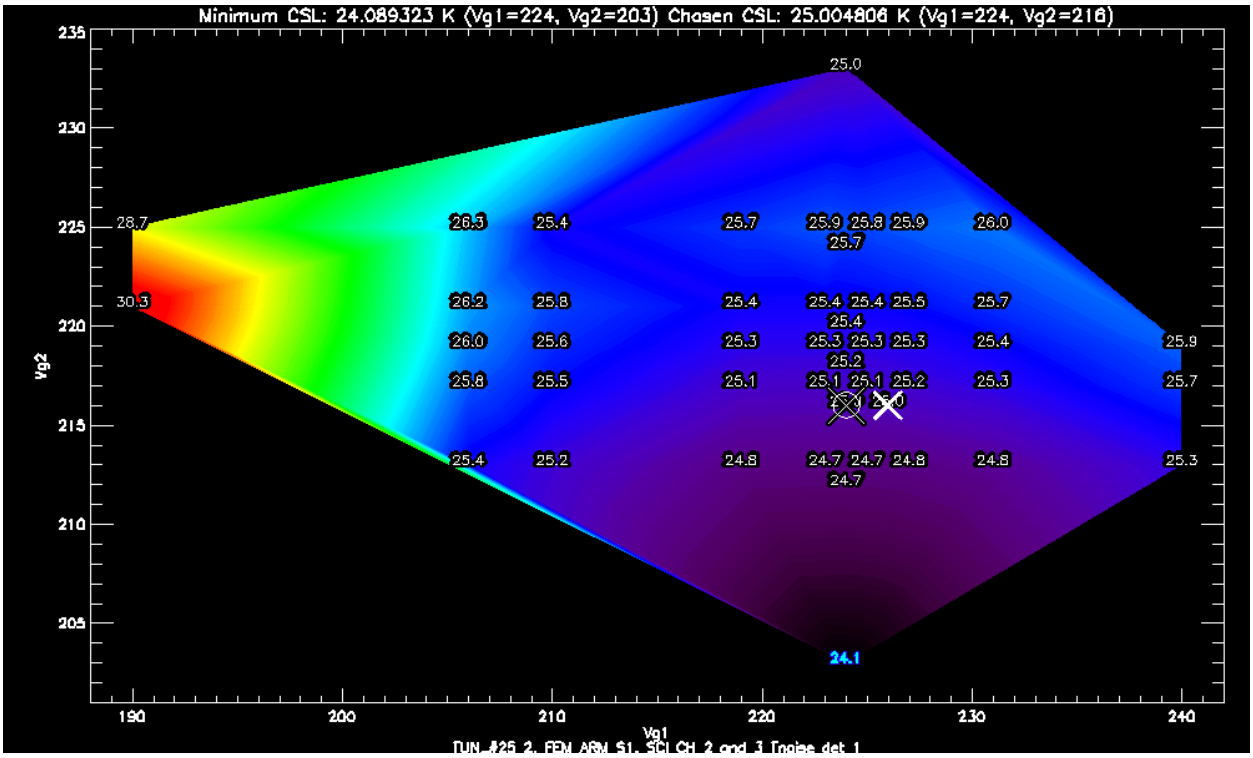
6.1.8 RCA25 Contour Plots

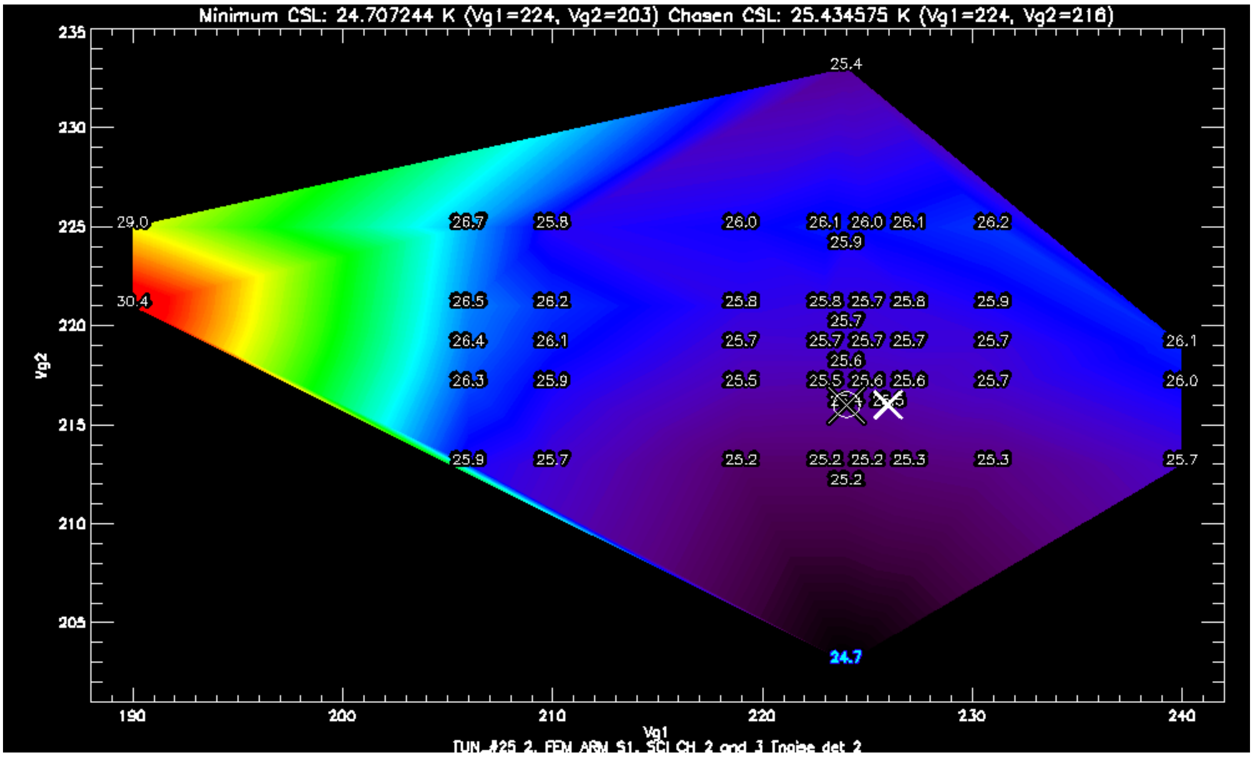


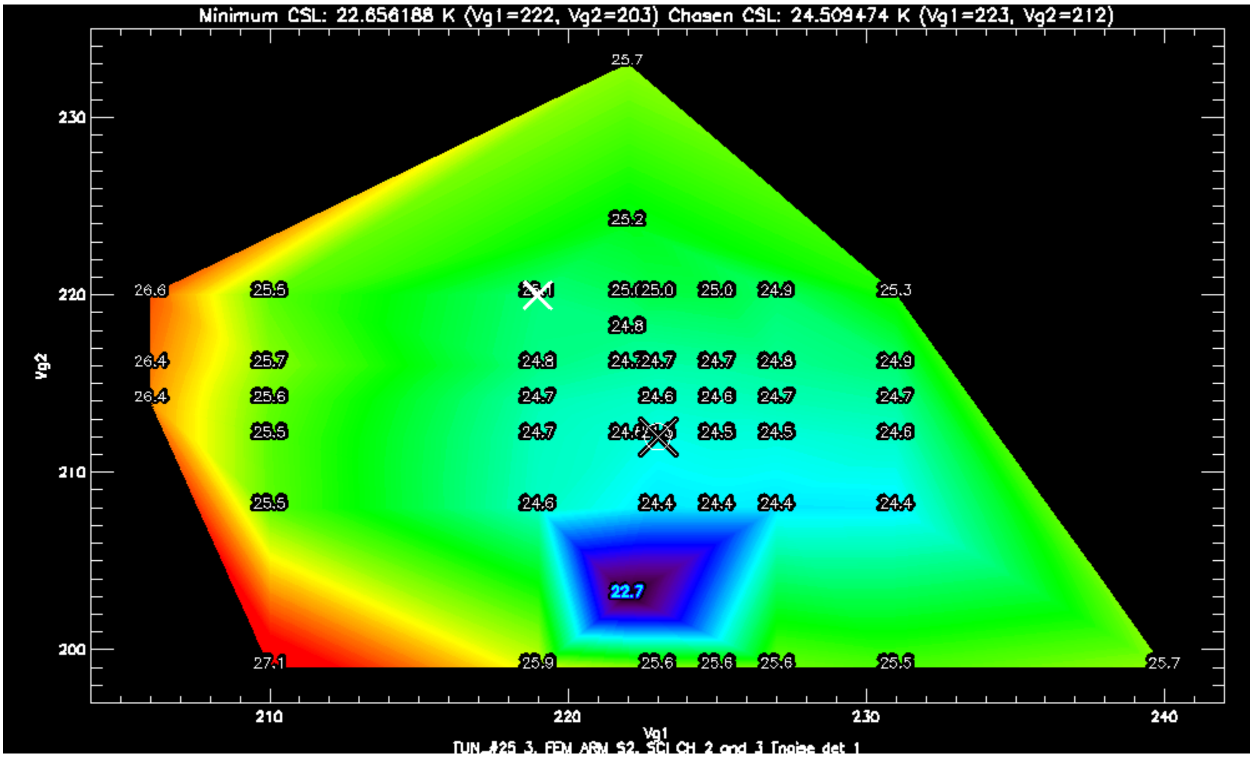


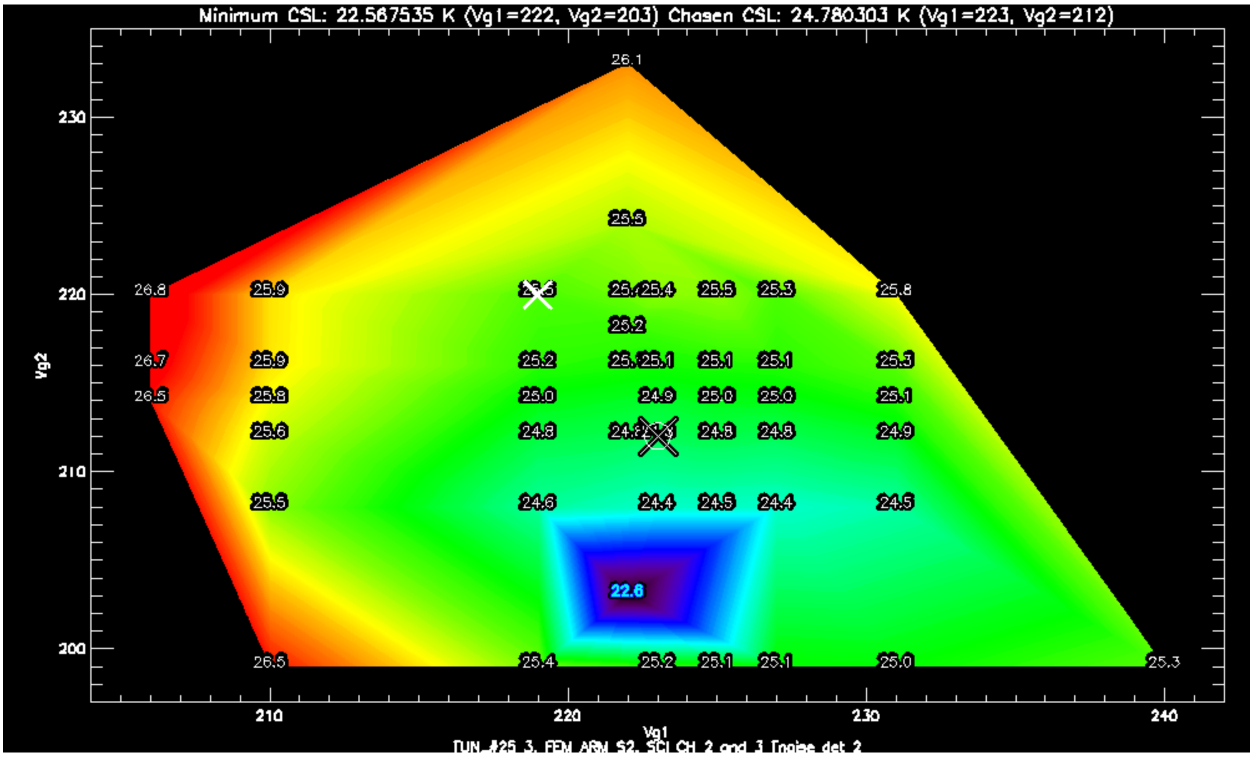

Minimum CSL: 28.603295 K (Vg1=219, Vg2=208) Chosen CSL: 28.766787 K (Vg1=219, Vg2=212)
Vg2
Vg1
TUN_#25_1, FEM ARM M2, SCI CH 0 and 1 Tnoise det 1


Minimum CSL: 27.966841 K (Vg1=219, Vg2=208) Chosen CSL: 28.163533 K (Vg1=219, Vg2=212)
Vg2
Vg1
TUN_#25_1, FEM ARM M2, SCI CH 0 and 1 Tnoise det 2

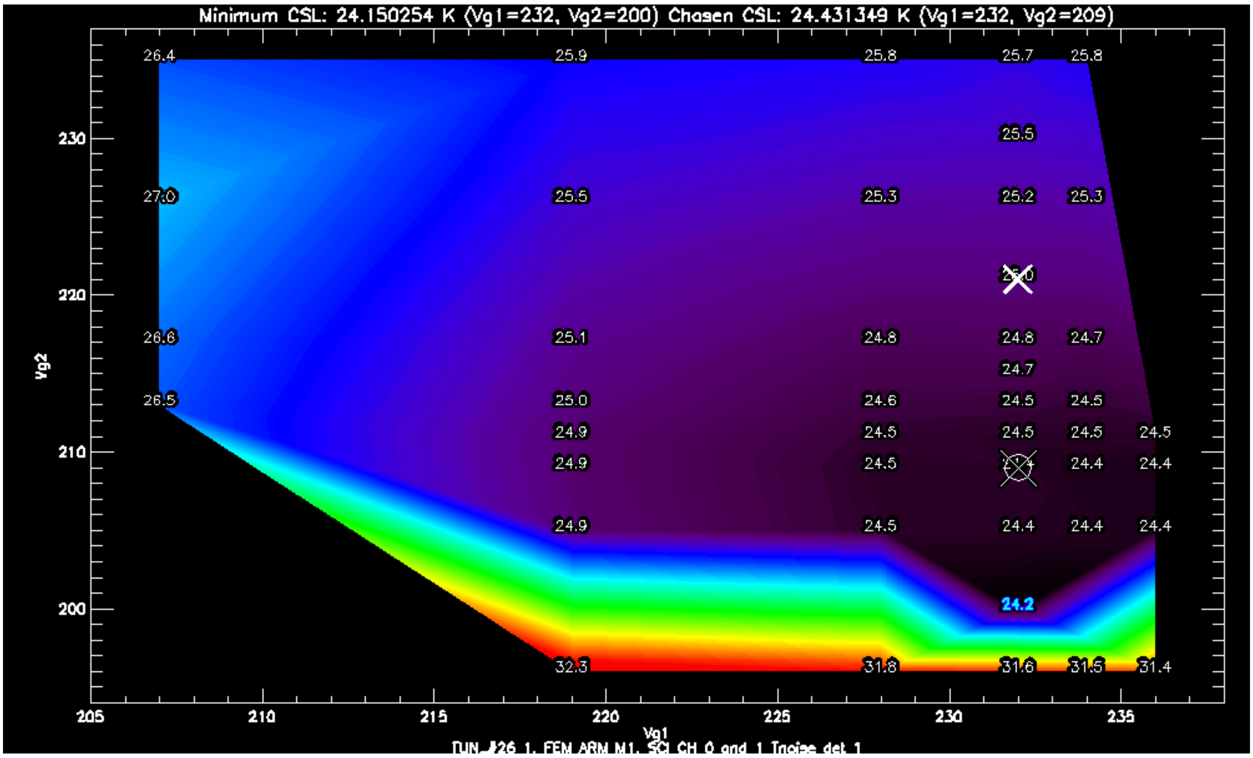

Minimum CSL: 24.089323 K (Vg1=224, Vg2=203) Chosen CSL: 25.004806 K (Vg1=224, Vg2=216)
Vg1
Vg2
TUN_#25_2, FEM ARM S1, SCI CH 2 and 3 [noise det 1

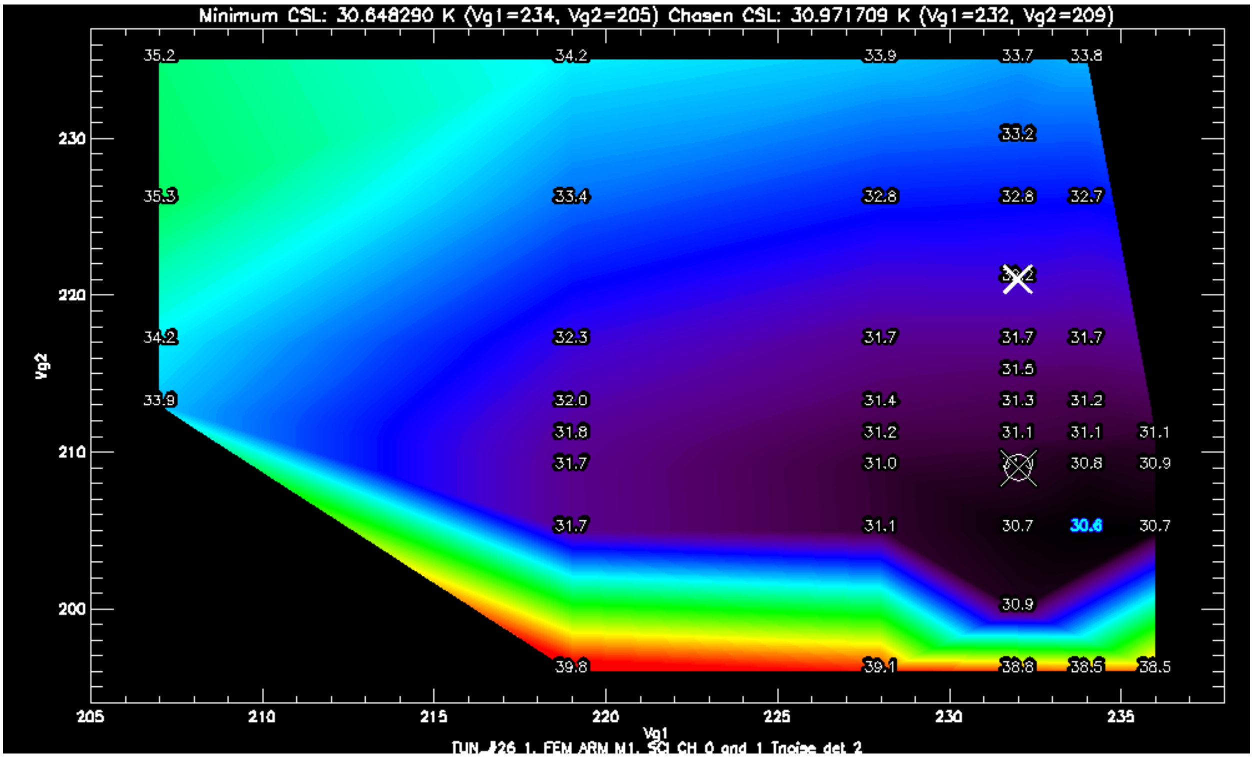

Minimum CSL: 24.707244 K (Vg1=224, Vg2=203) Chosen CSL: 25.434575 K (Vg1=224, Vg2=216)
Vg1
Vg2
TUN_#25_2, FEM ARM S1, SCI CH 2 and 3 [noise det 2

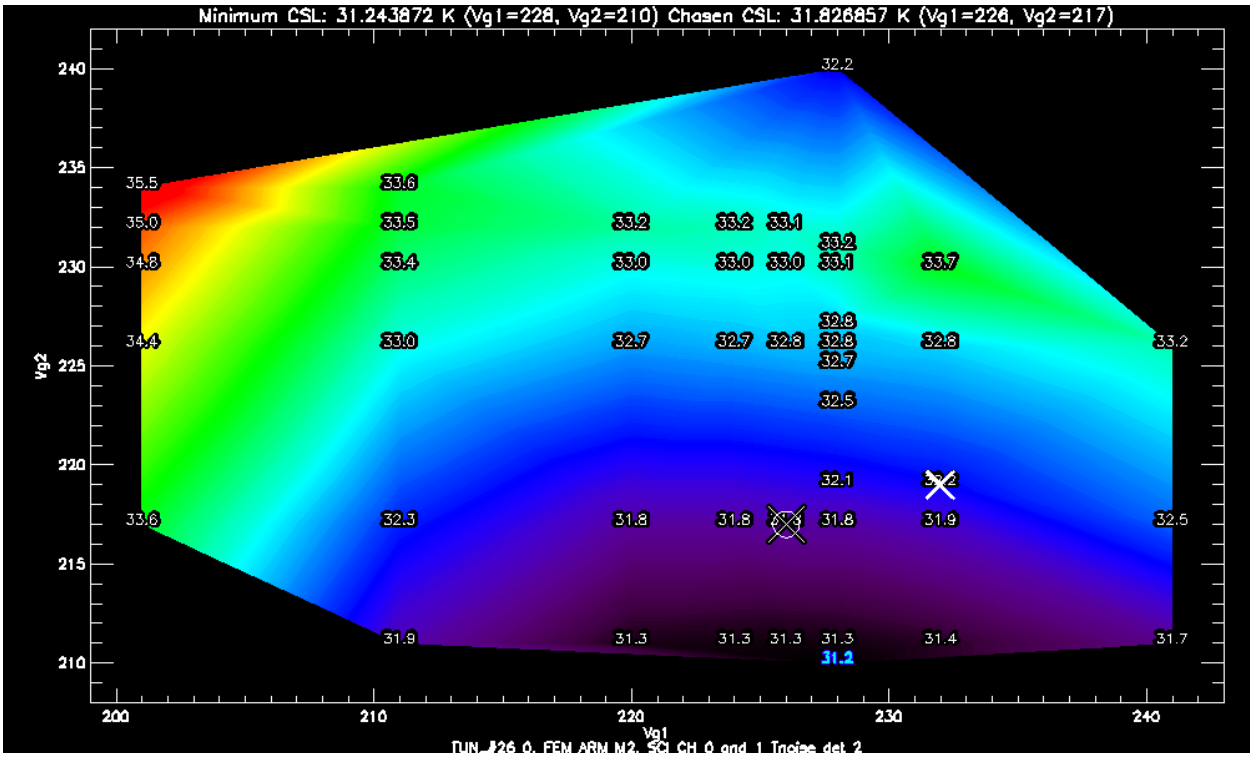

Minimum CSL: 22.656188 K (Vg1=222, Vg2=203) Chosen CSL: 24.509474 K (Vg1=223, Vg2=212)
Vg2
Vg1
TUN_#25 3, FEM ARM S2, SCI CH 2 and 3 [noise det 1

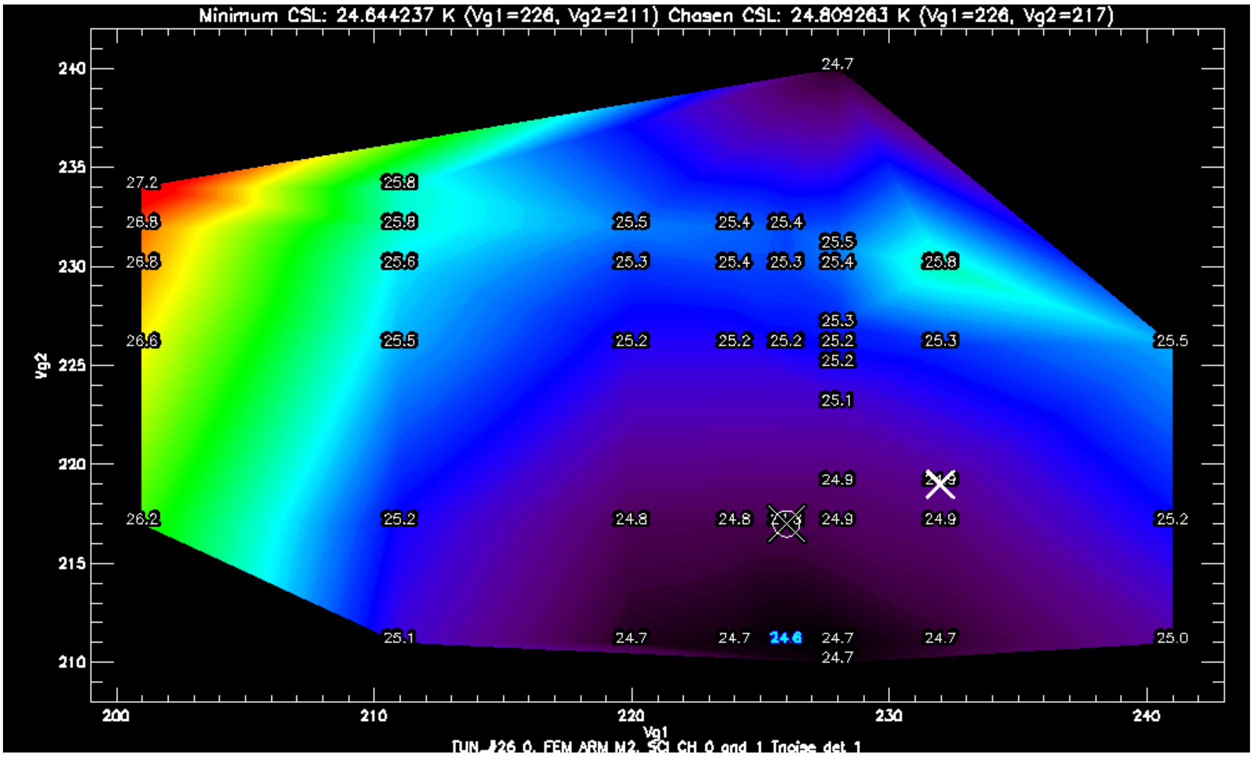

Minimum CSL: 22.567535 K (Vg1=222, Vg2=203) Chosen CSL: 24.780303 K (Vg1=223, Vg2=212)
Vg2
Vg1
TUN_#25 3, FEM ARM S2, SCI CH 2 and 3 [noise det 2

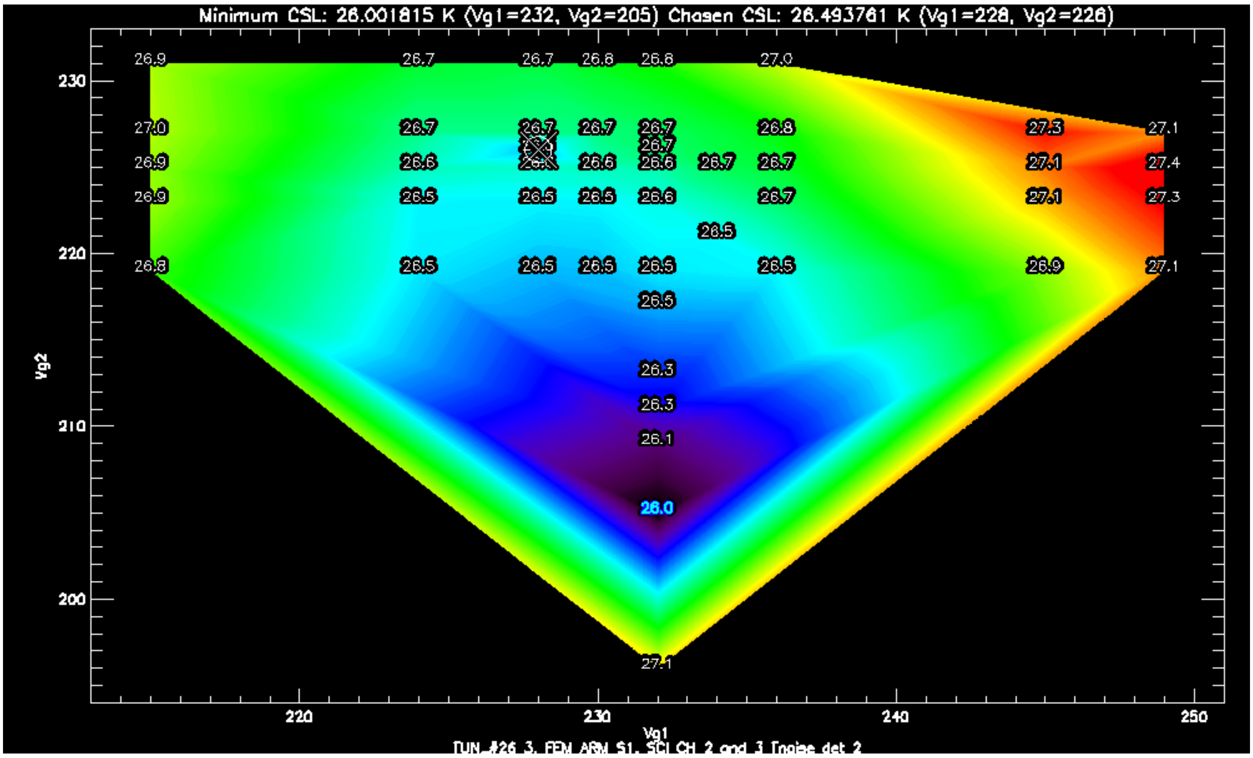
6.1.9 RCA26 Contour Plots

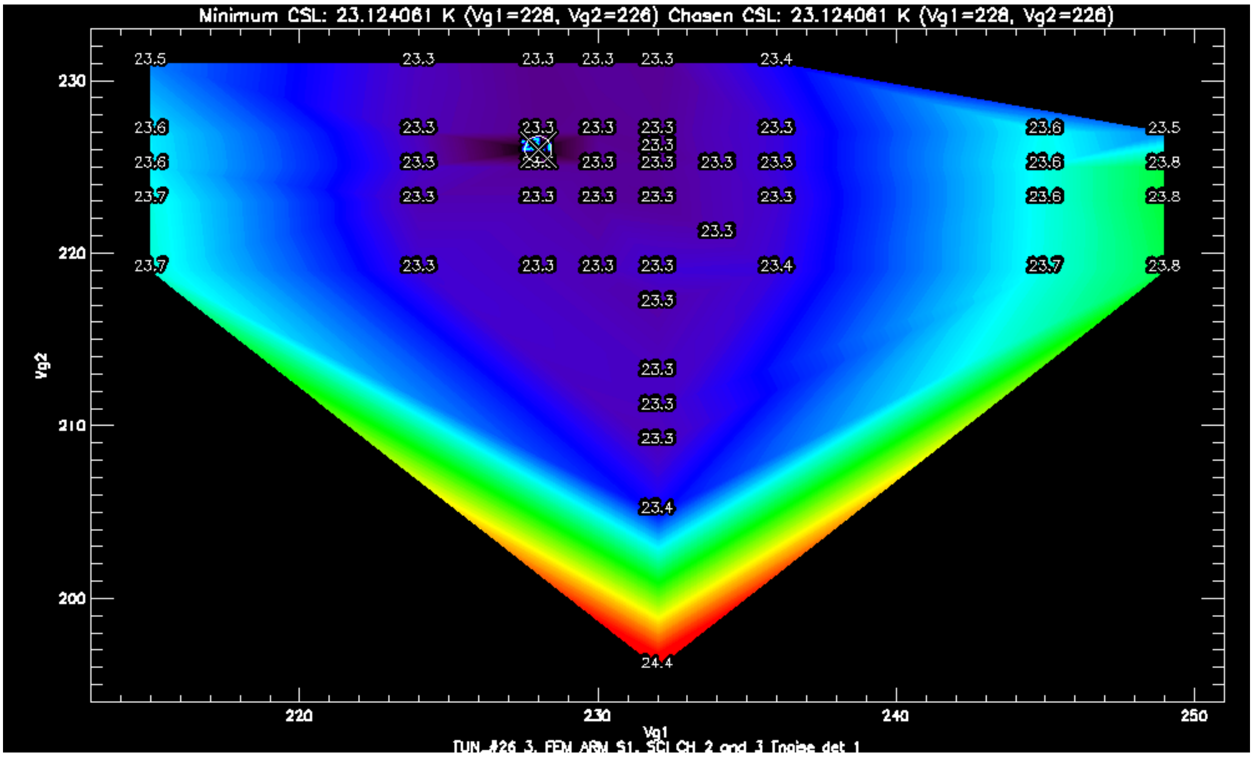


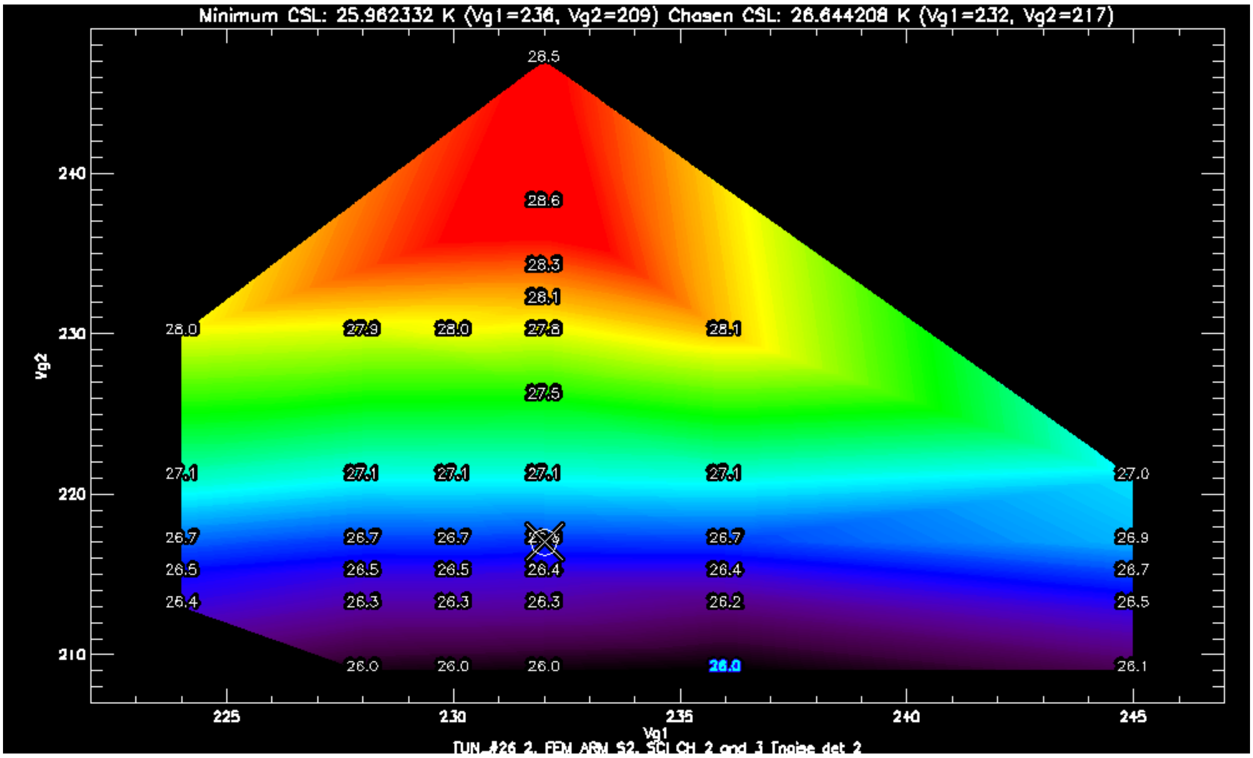


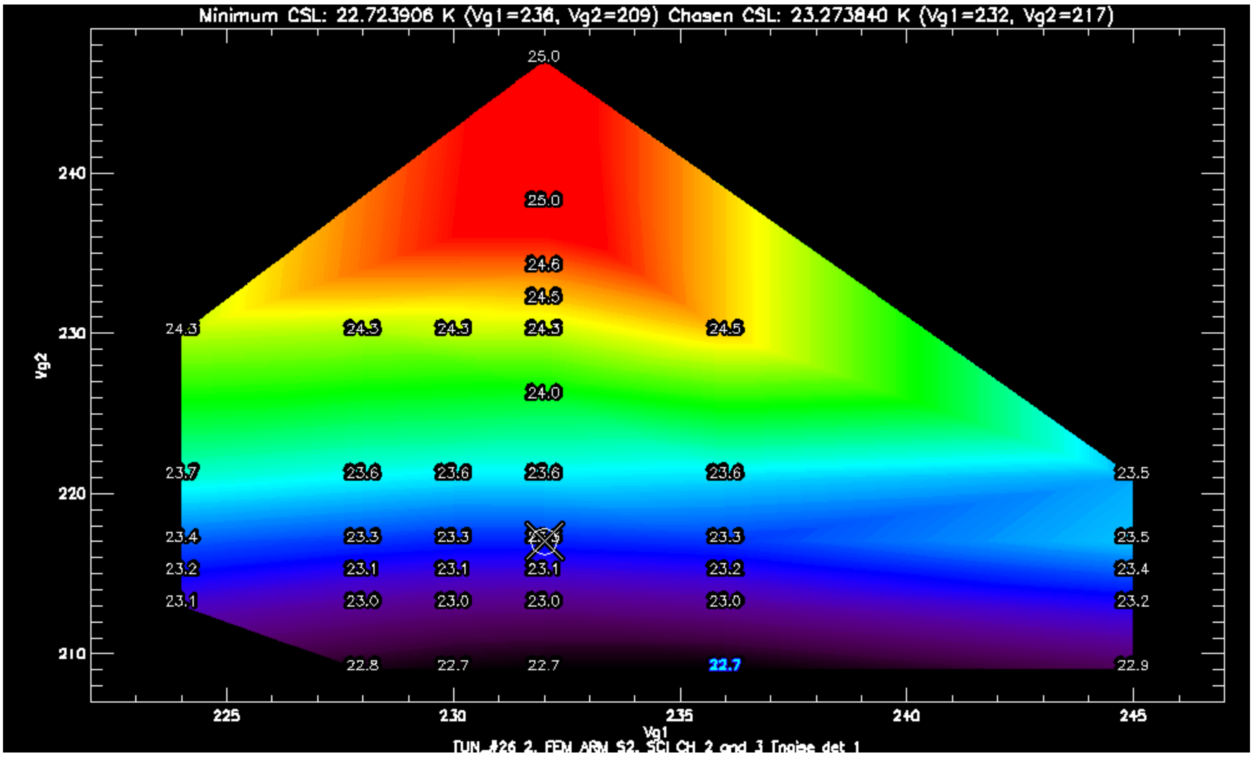

Minimum CSL: 31.243872 K (Vg1=228, Vg2=210) Chosen CSL: 31.826857 K (Vg1=226, Vg2=217)
Vg1
Vg2
TUN_#26 0, FEM ARM M2, SCI CH 0 and 1 Tnoise det 2


Minimum CSL: 24.644237 K (Vg1=226, Vg2=211) Chosen CSL: 24.809263 K (Vg1=226, Vg2=217)
Vg1
Vg2
TUN_#26 0, FEM ARM M2, SCI CH 0 and 1 Tnoise det 1

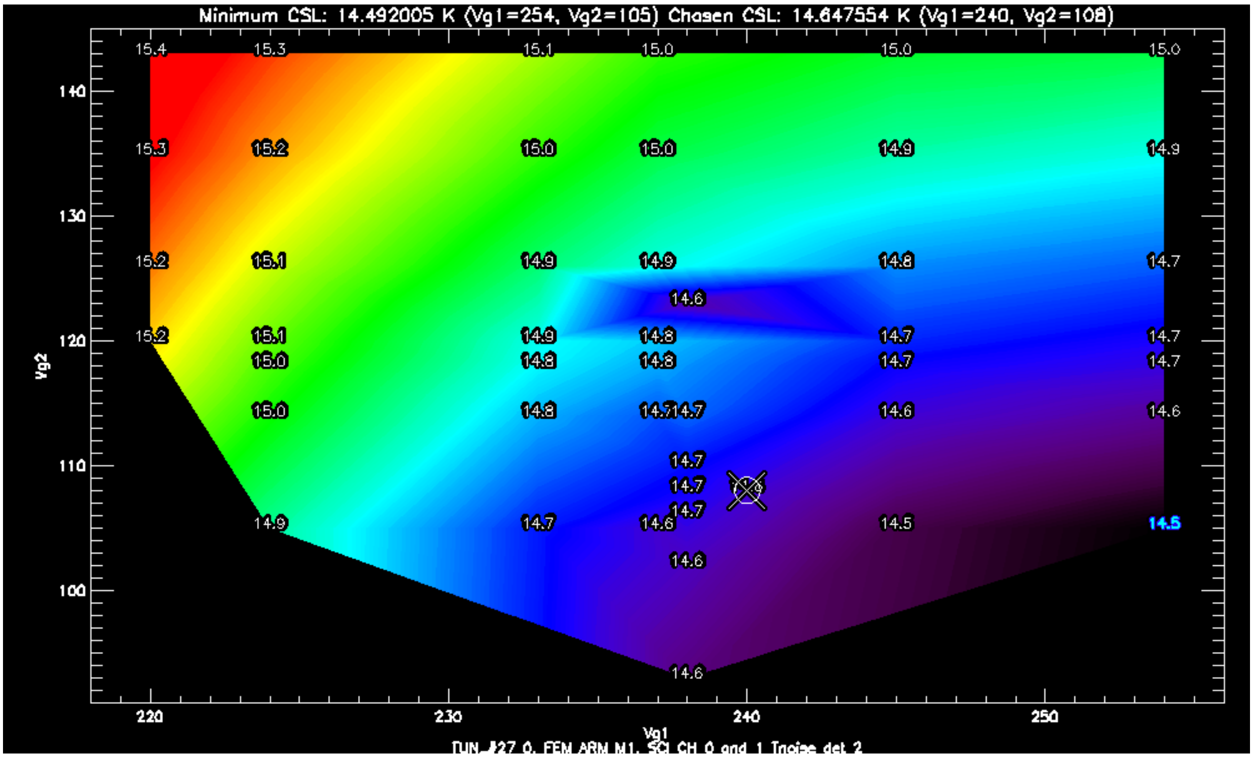

Minimum CSL: 26.001815 K (Vg1=232, Vg2=205) Chosen CSL: 26.493761 K (Vg1=228, Vg2=226)
Vg2
Vg1
TUN_#26_3, FEM ARM S1, SCI CH 2 and 3 [noise det 2

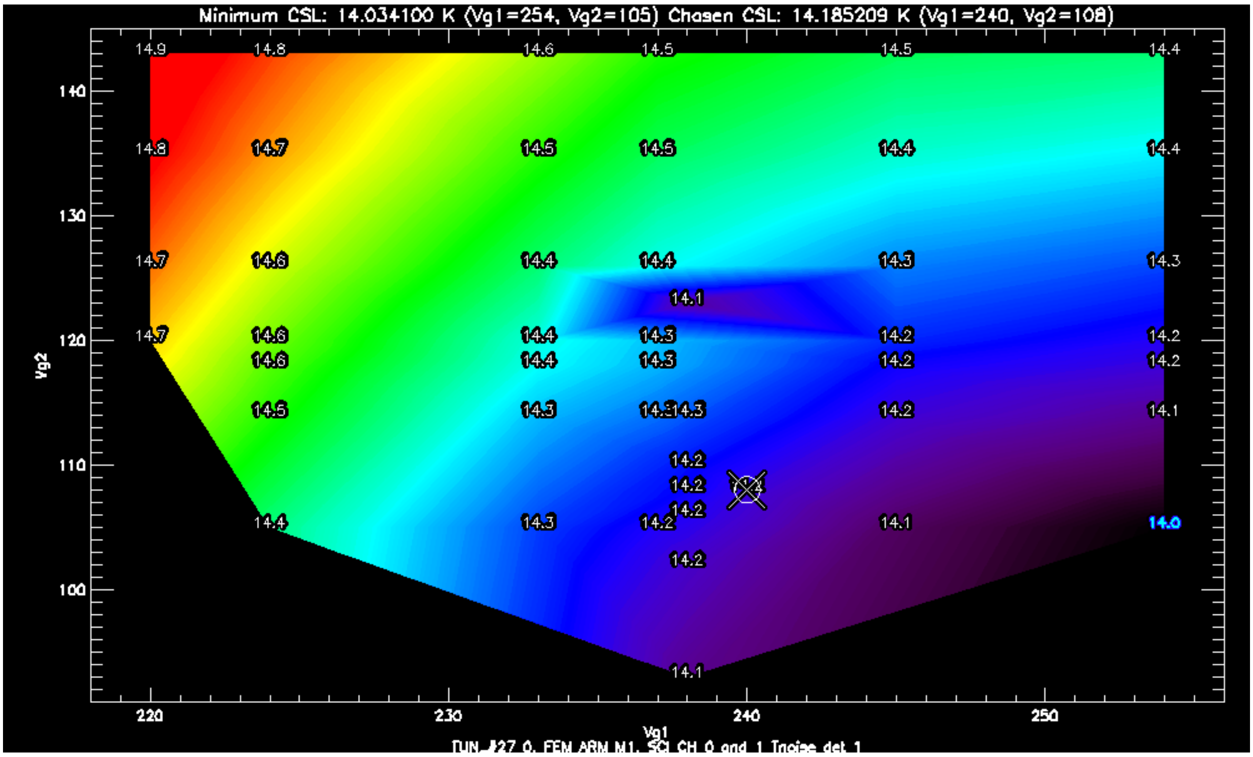

Minimum CSL: 23.124061 K (Vg1=228, Vg2=226) Chosen CSL: 23.124061 K (Vg1=228, Vg2=226)
Vg2
Vg1
TUN_#26_3, FEM ARM S1, SCI CH 2 and 3 [noise det 1

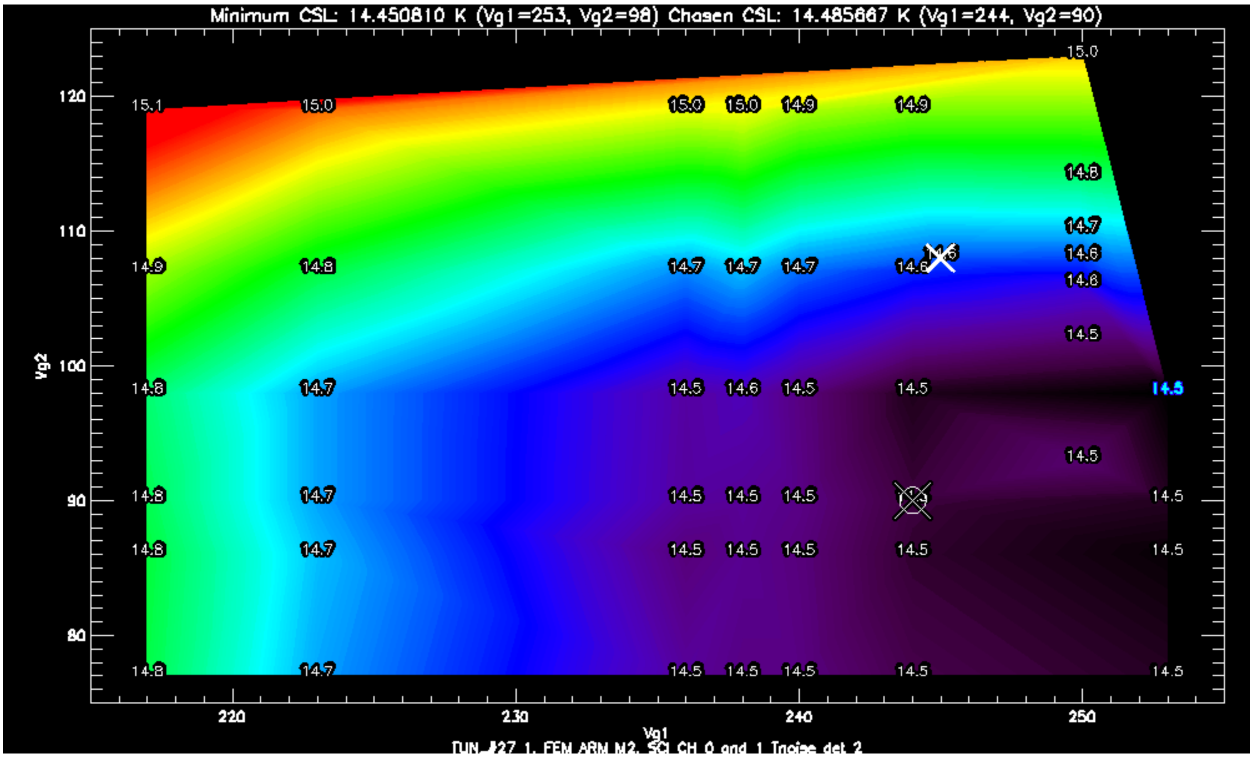

Minimum CSL: 25.962332 K (Vg1=236, Vg2=209) Chosen CSL: 26.644208 K (Vg1=232, Vg2=217)
Vg2
Vg1
225
230
235
240
245
210
220
230
240
TUN_#26 2. FEM ARM S2. SCI CH 2 and 3 Tnoise det 2

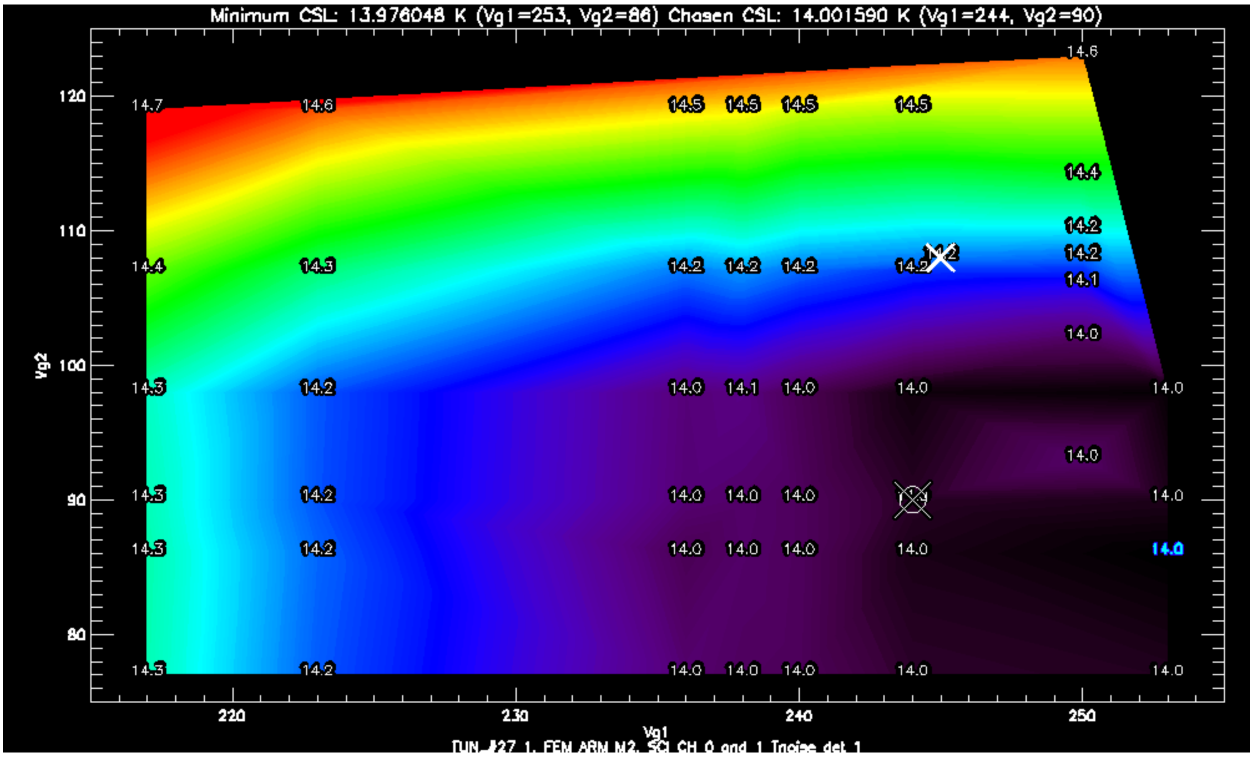

Minimum CSL: 22.723906 K (Vg1=236, Vg2=209) Chosen CSL: 23.273840 K (Vg1=232, Vg2=217)
Vg2
Vg1
225
230
235
240
245
210
220
230
240
TUN_#26 2. FEM ARM S2. SCI CH 2 and 3 Tnoise det 1

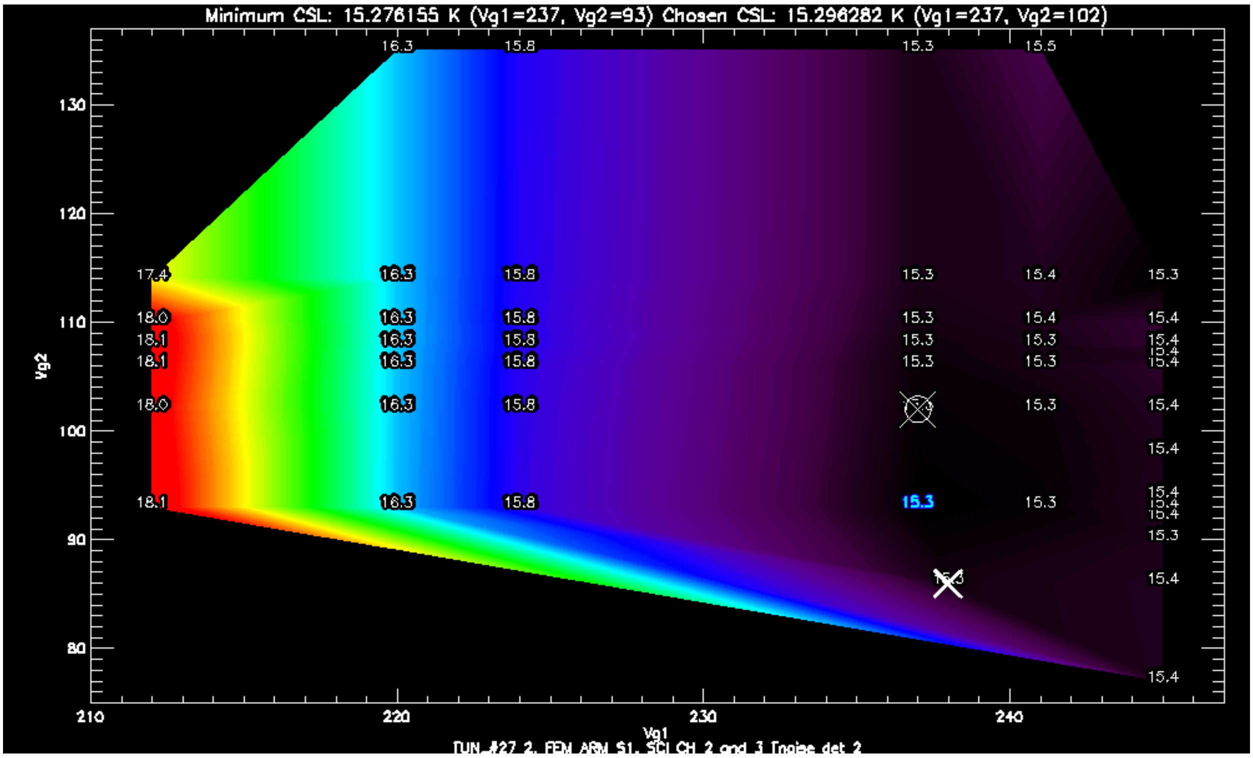
6.1.10 RCA27 Contour Plots

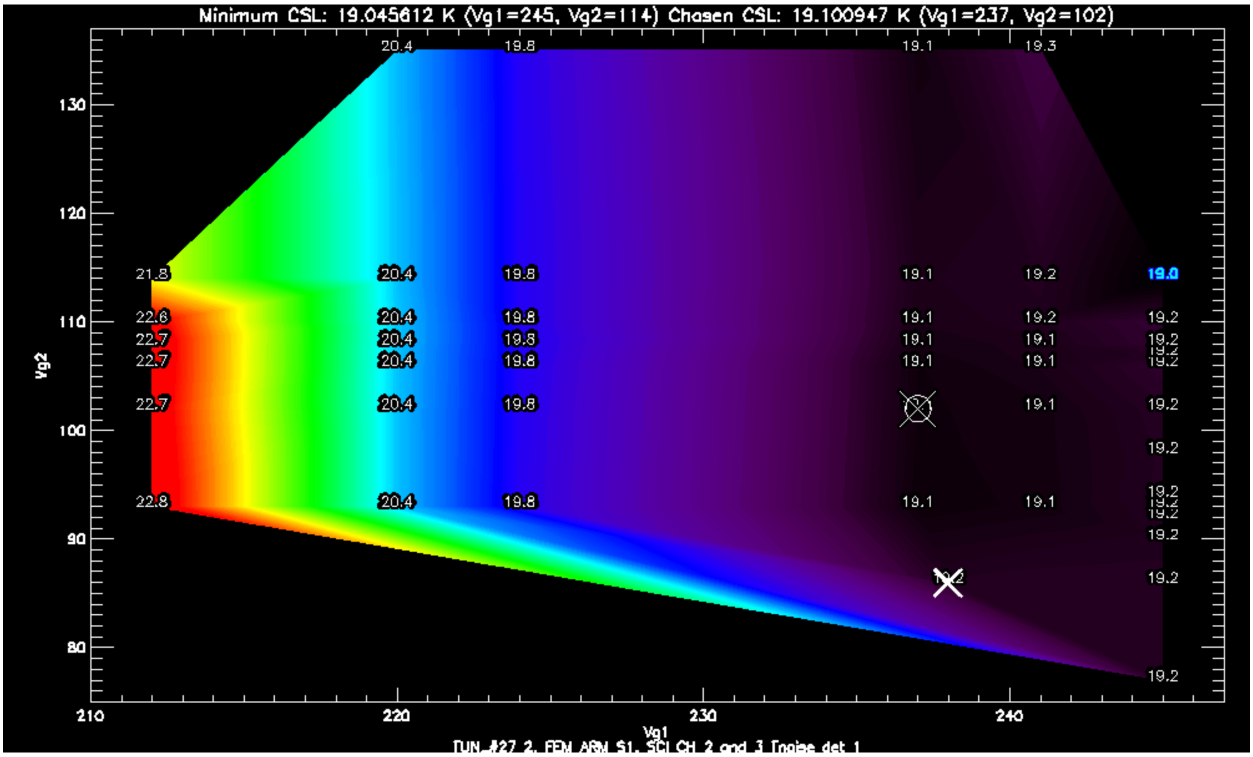


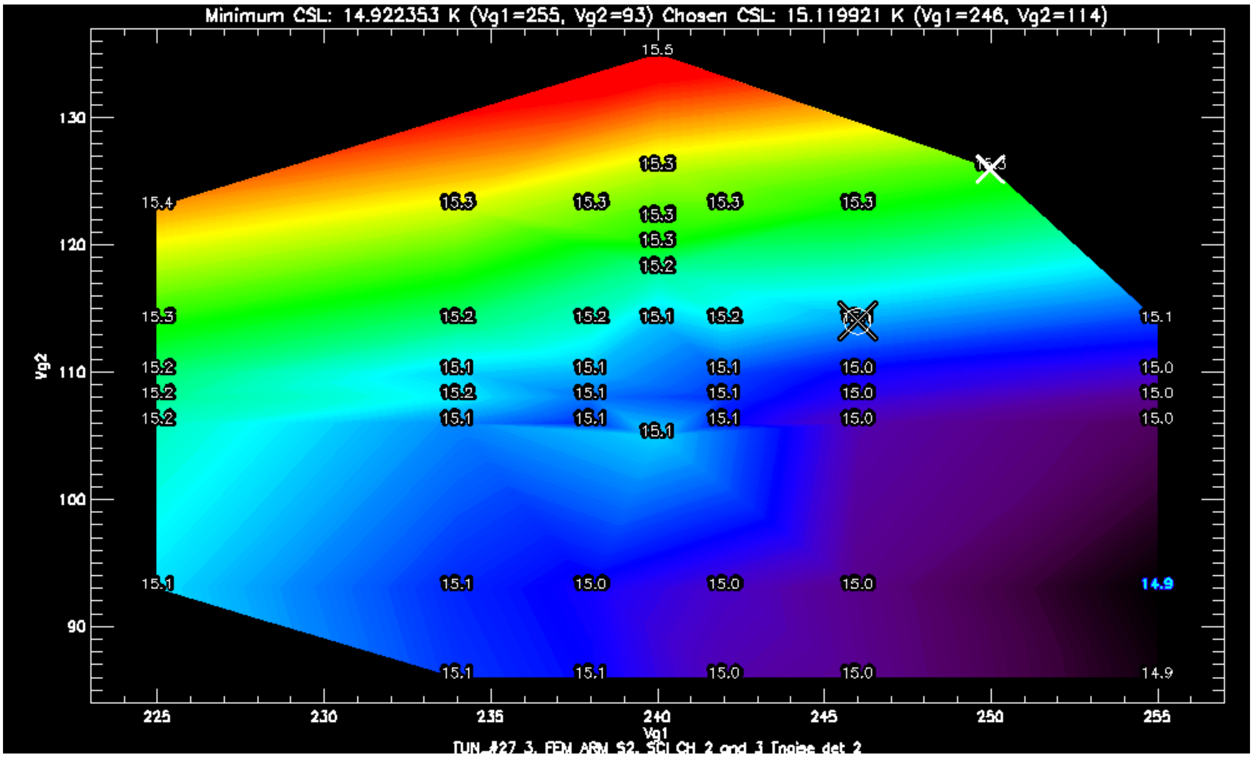


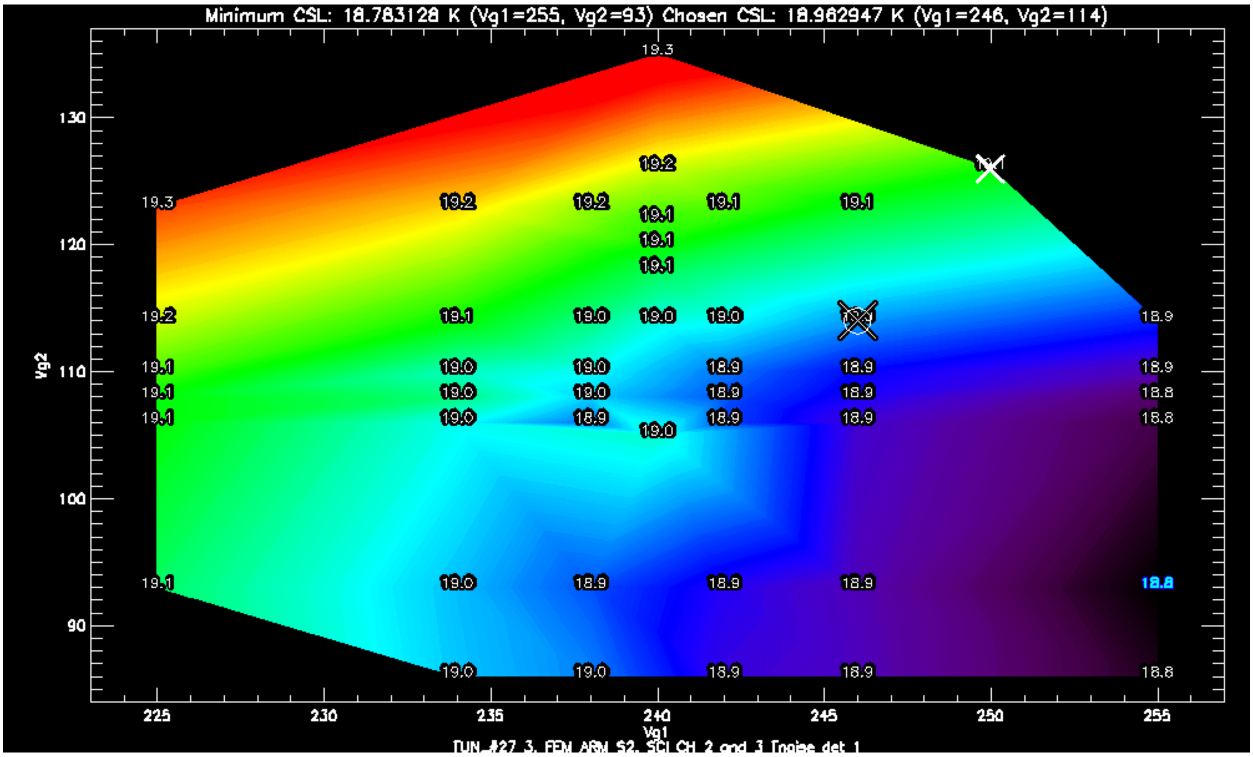

Minimum CSL: 14.450810 K (Vg1=253, Vg2=98) Chosen CSL: 14.485667 K (Vg1=244, Vg2=90)
Vg2
Vg1
220
230
240
250
80
90
100
110
120
TUN_#27 1, FEM ARM M2, SCI CH 0 and 1 Tnoise det 2


Minimum CSL: 13.976048 K (Vg1=253, Vg2=86) Chosen CSL: 14.001590 K (Vg1=244, Vg2=90)
Vg2
Vg1
220
230
240
250
80
90
100
110
120
TUN_#27 1, FEM ARM M2, SCI CH 0 and 1 Tnoise det 1

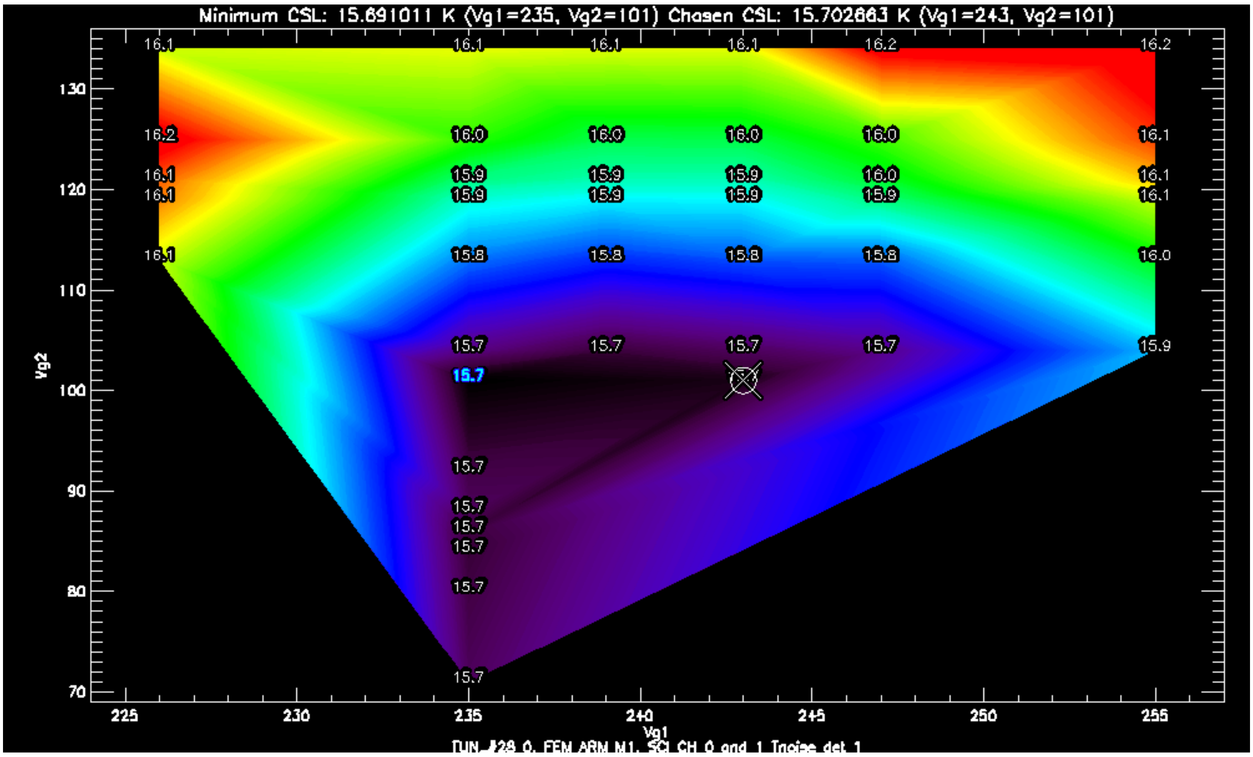

Minimum CSL: 15.276155 K (Vg1=237, Vg2=93) Chosen CSL: 15.298282 K (Vg1=237, Vg2=102)
Vg2
Vg1
RUN #27 2. FEM ARM S1. SCI CH 2 and 3 [noise det 2

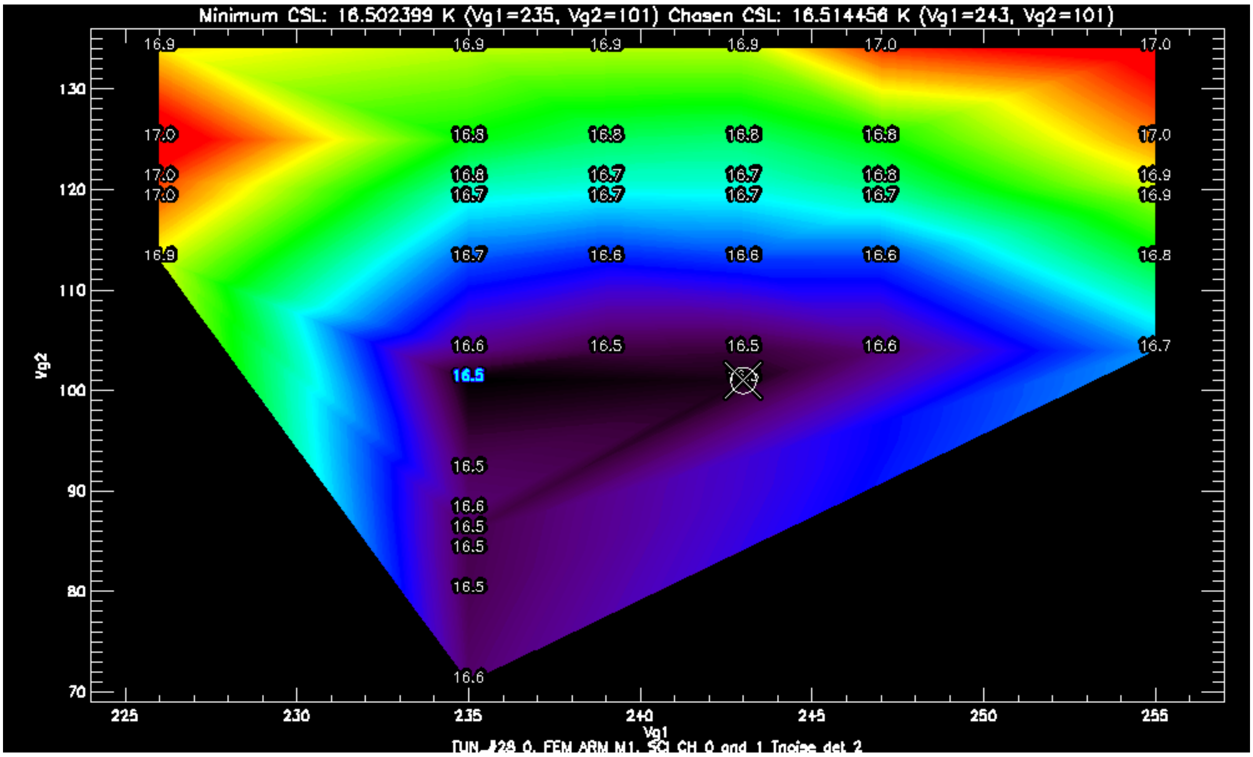

Minimum CSL: 19.045612 K (Vg1=245, Vg2=114) Chosen CSL: 19.100947 K (Vg1=237, Vg2=102)
Vg2
Vg1
RUN #27 2. FEM ARM S1. SCI CH 2 and 3 [noise det 1

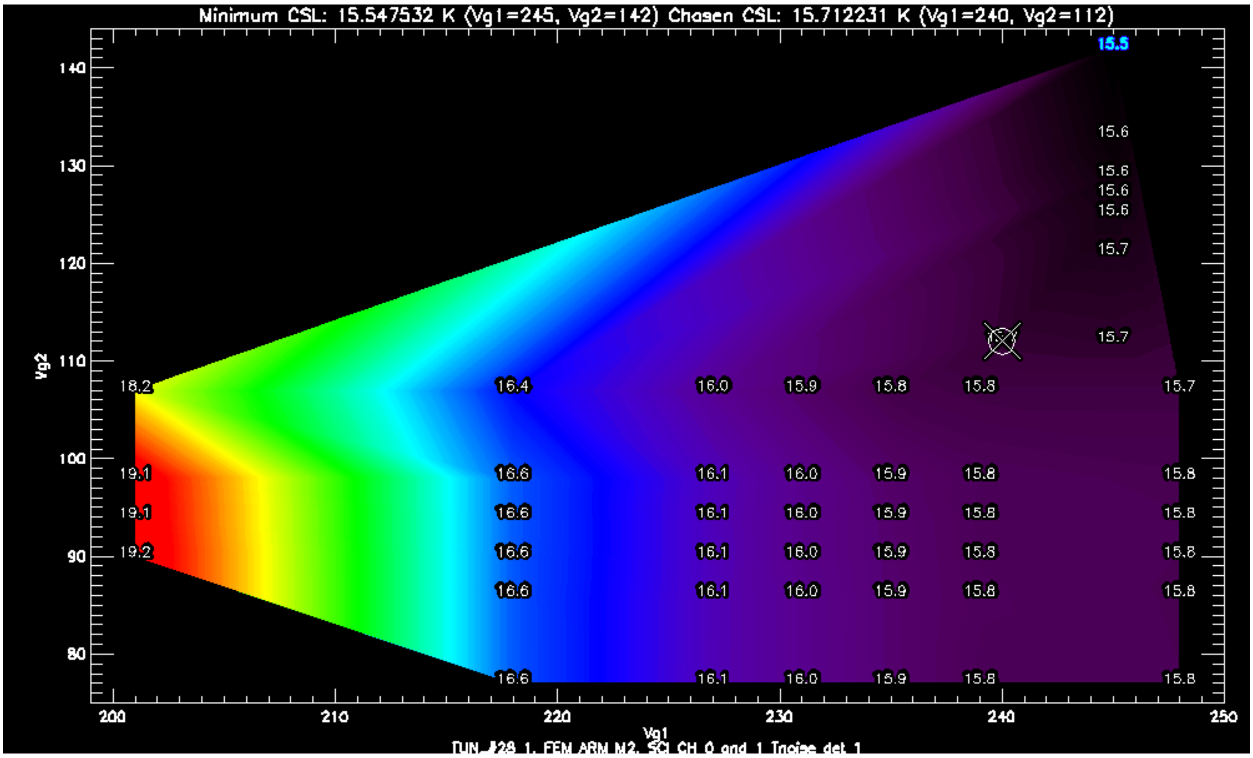

Minimum CSL: 14.922353 K (Vg1=255, Vg2=93) Chosen CSL: 15.119921 K (Vg1=246, Vg2=114)
Vg2
Vg1
TUN_#27_3, FEM ARM S2, SCI CH 2 and 3 Tnoise det 2

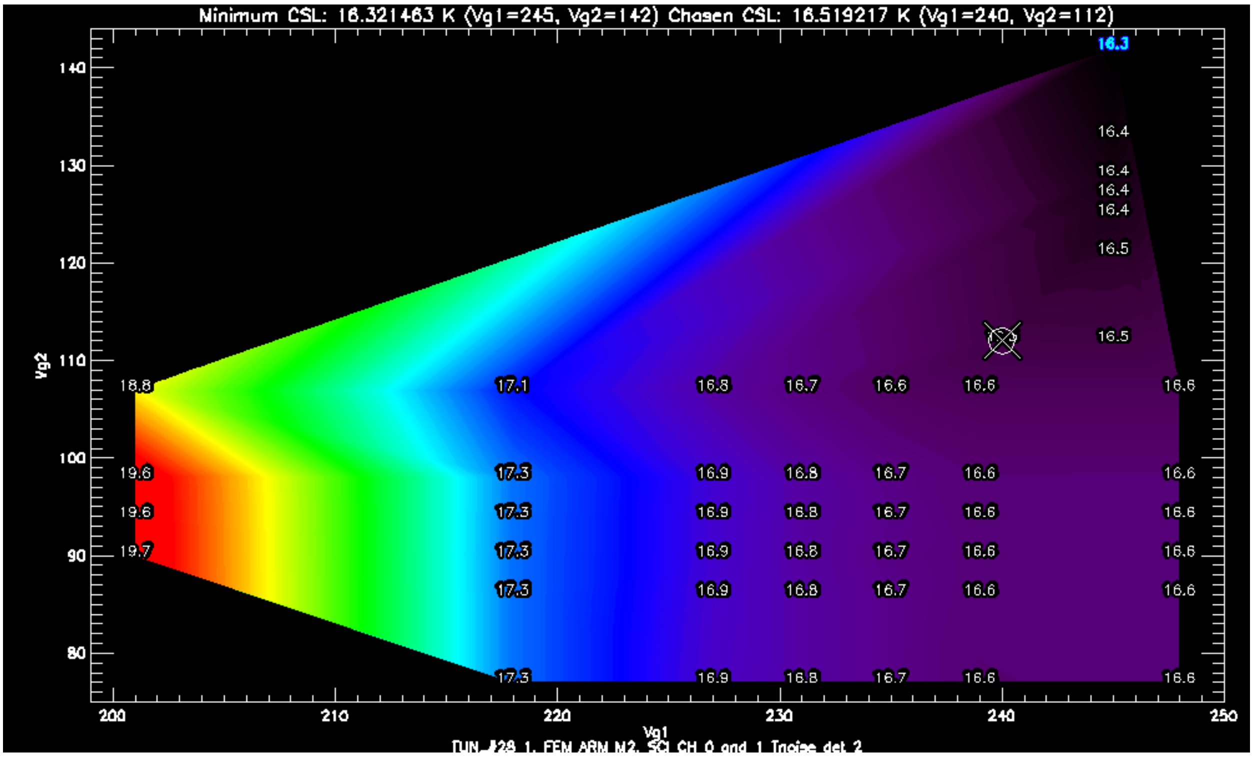

Minimum CSL: 18.783128 K (Vg1=255, Vg2=93) Chosen CSL: 18.962947 K (Vg1=246, Vg2=114)
Vg2
Vg1
TUN_#27_3, FEM ARM S2, SCI CH 2 and 3 Tnoise det 1

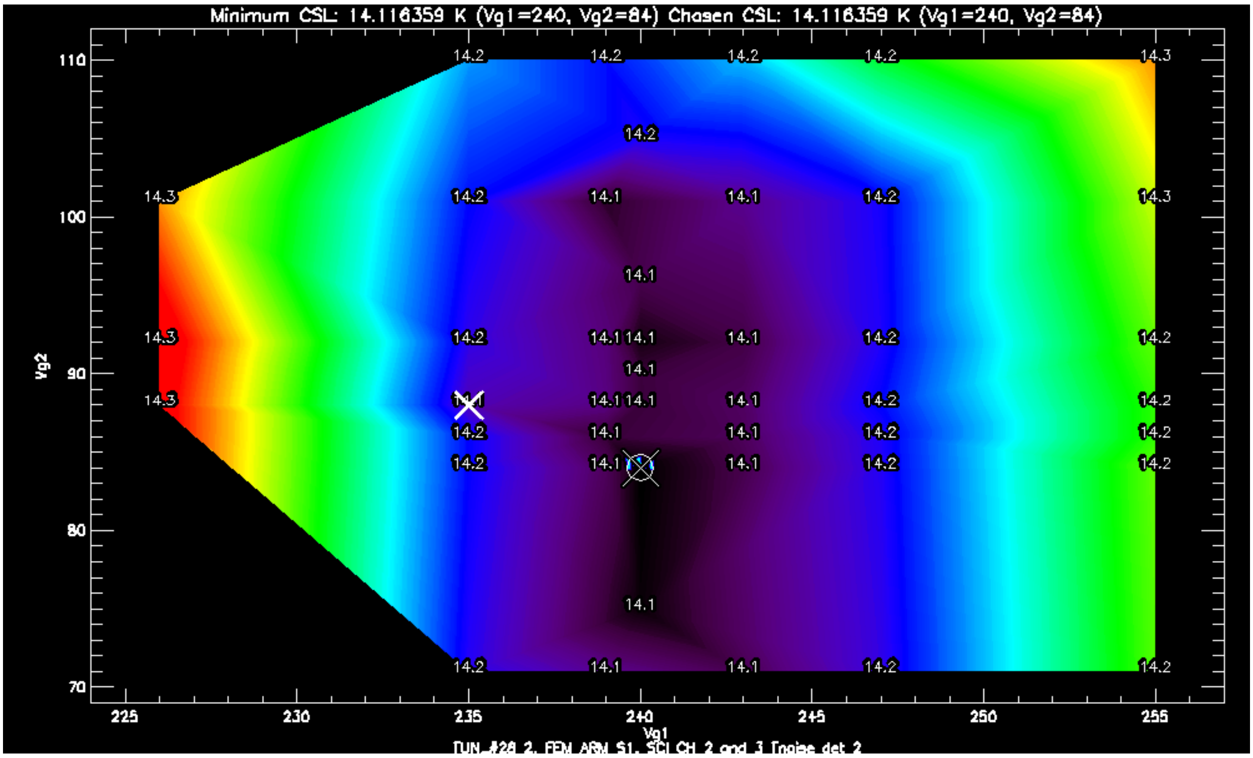
6.1.11 RCA28 Contour Plots

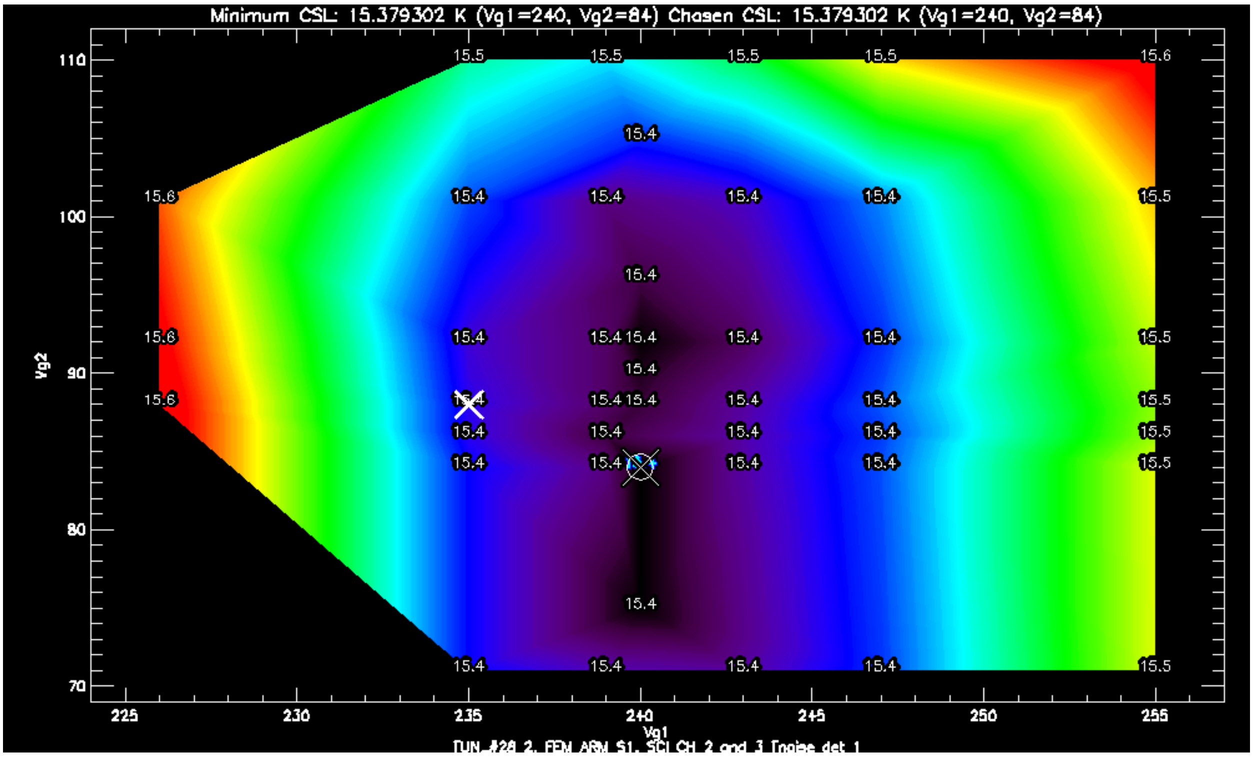


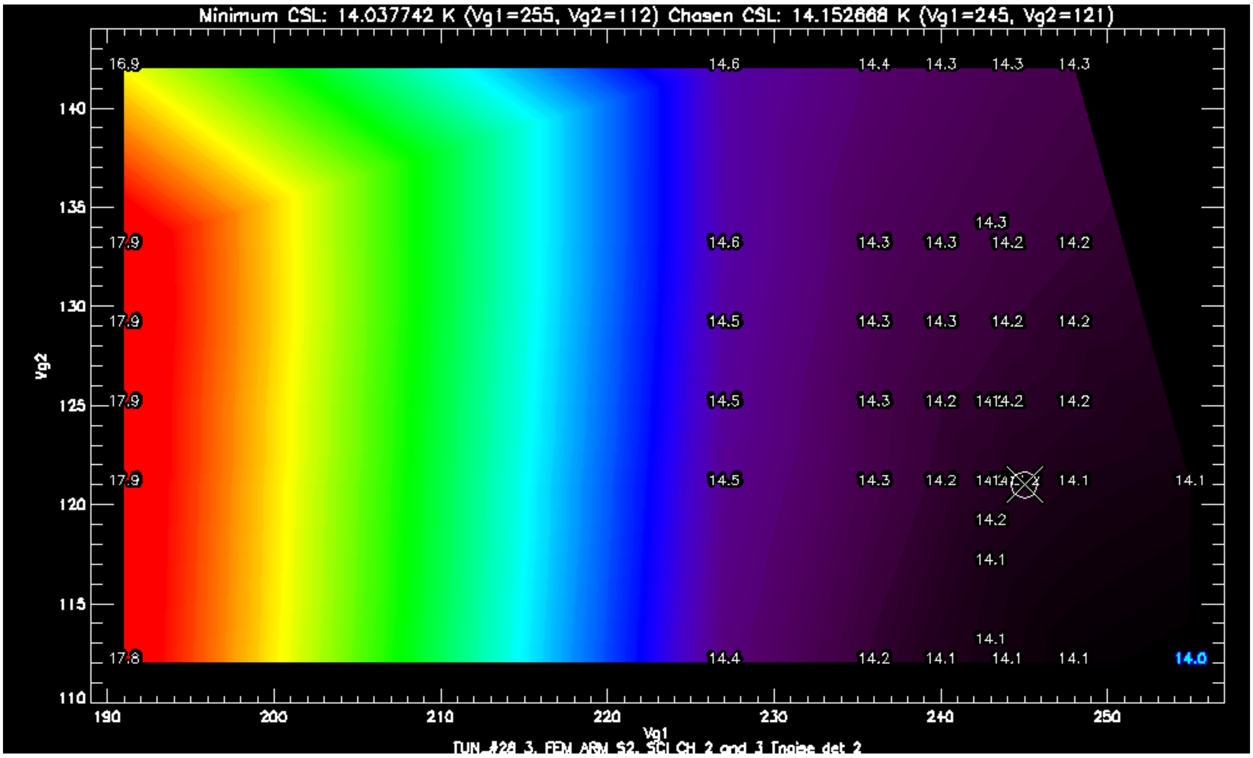


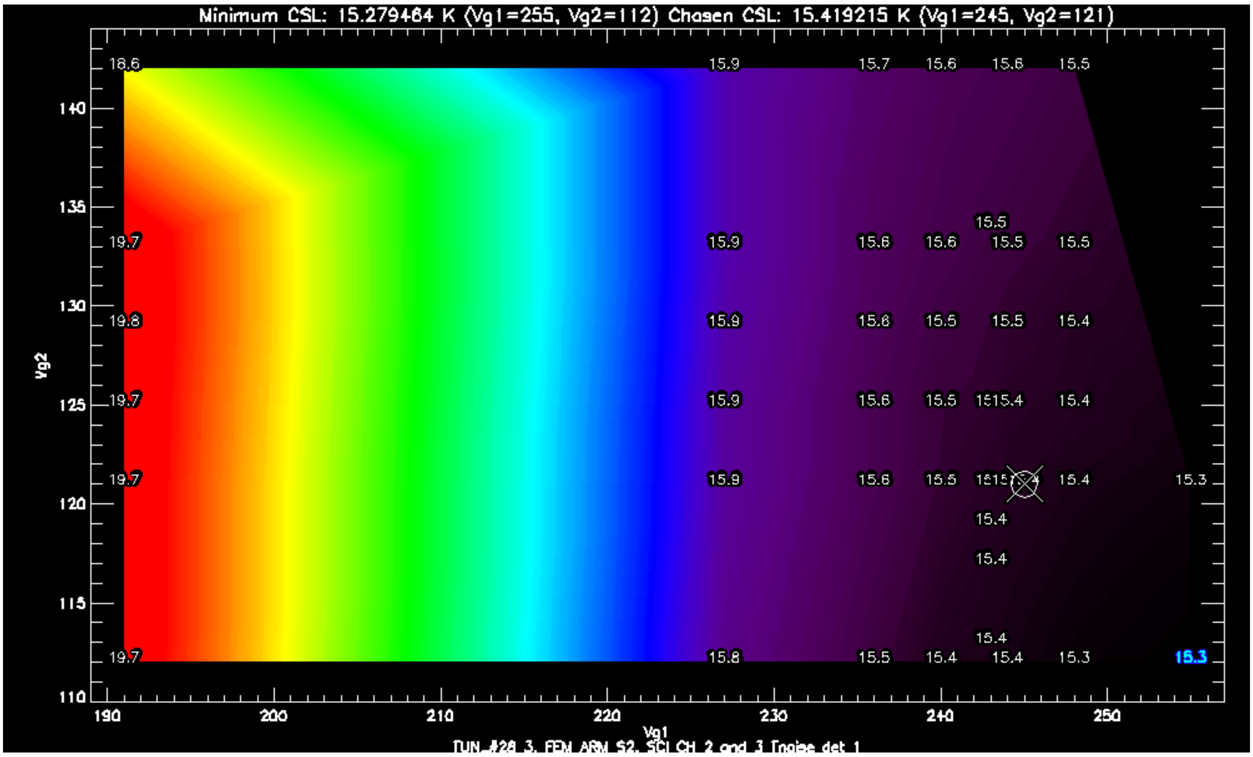

Minimum CSL: 15.547532 K (Vg1=245, Vg2=142) Chosen CSL: 15.712231 K (Vg1=240, Vg2=112)
Vg2
Vg1
TUN_#28 1, FEM ARM M2, SCI CH 0 and 1 Tnoise det 1


Minimum CSL: 16.321463 K (Vg1=245, Vg2=142) Chosen CSL: 16.519217 K (Vg1=240, Vg2=112)
Vg2
Vg1
TUN_#28 1, FEM ARM M2, SCI CH 0 and 1 Tnoise det 2


Minimum CSL: 14.116359 K (Vg1=240, Vg2=84) Chosen CSL: 14.116359 K (Vg1=240, Vg2=84)
Vg2
Vg1
TUN_#28 2, FEM ARM S1, SCI CH 2 and 3 Tnoise det 2


Minimum CSL: 15.379302 K (Vg1=240, Vg2=84) Chosen CSL: 15.379302 K (Vg1=240, Vg2=84)
Vg2
Vg1
TUN_#28 2, FEM ARM S1, SCI CH 2 and 3 Tnoise det 1


Minimum CSL: 14.037742 K (Vg1=255, Vg2=112) Chosen CSL: 14.152668 K (Vg1=245, Vg2=121)
Vg2
Vg1
TUN_#28 3. FEM ARM S2. SCI CH 2 and 3 [noise det 2


Minimum CSL: 15.279464 K (Vg1=255, Vg2=112) Chosen CSL: 15.419215 K (Vg1=245, Vg2=121)
Vg2
Vg1
TUN_#28 3. FEM ARM S2. SCI CH 2 and 3 [noise det 1

7 COMMENTS

There are still problems in data analysis which are not depending on the analysis script and routines. Mainly, as also reported in [RD6], the last point before a change in both the Vg1 and Vg2 often shows a wrong level due to the some delay in the recording of housekeeping with respect to scientific signal. Actually the scientific data of the last point is averaged over a time windows that includes also changes in amplifier biases. In the following plots an example from the last two steps in the RCA25 S2 amplifier tuning is reported, where a strong discontinuity is evident in the corresponding contour plot.

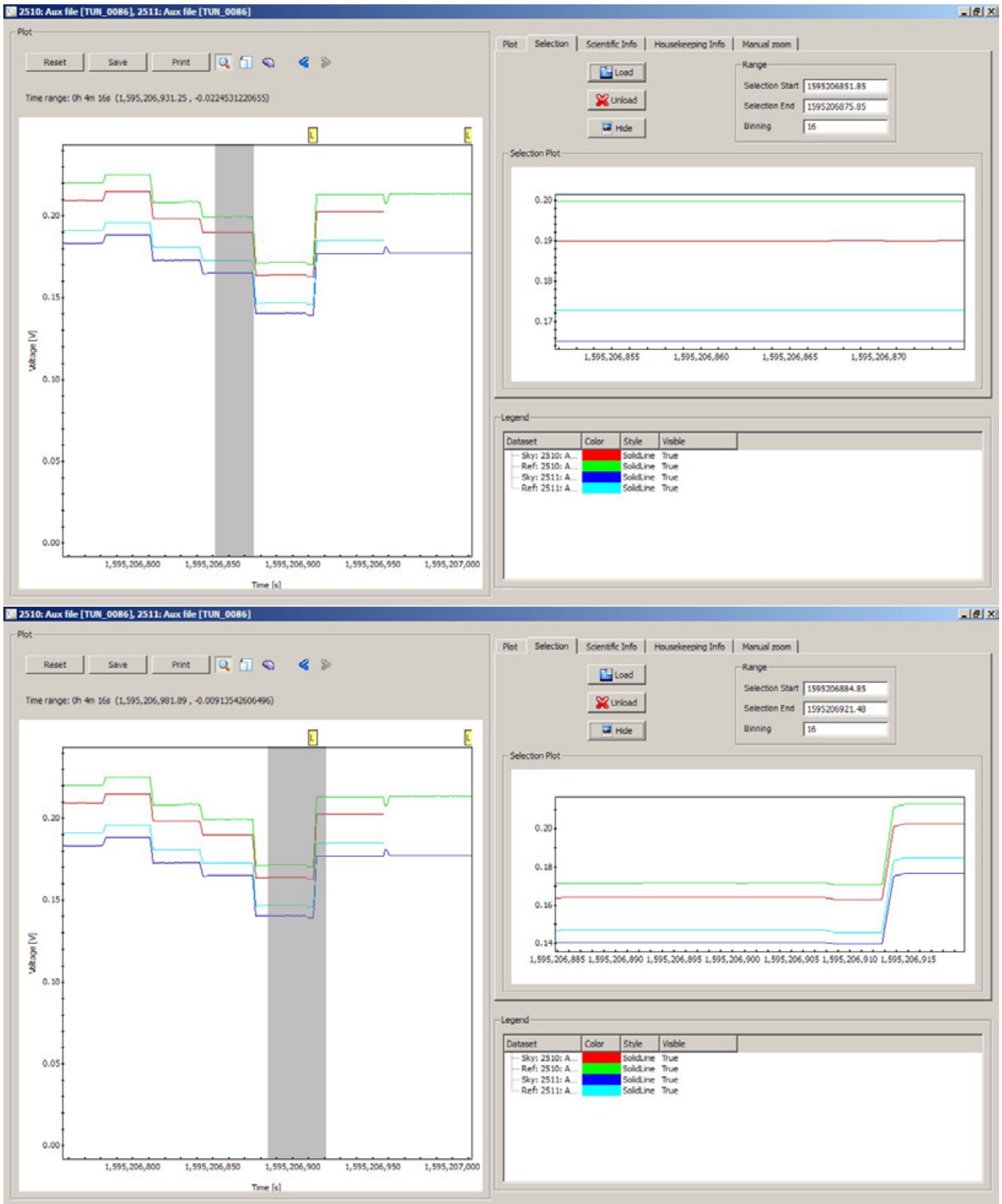


Figure 3 The last two steps in the RCA25 S2 amplifier tuning. The final step, before going back to nominal biases, is affected by a wrong selection due to the delay in recording the change of both Vg1, Vg2 bias. This is not affecting previous steps because the smaller delay was covered by the cropping of last seconds before change.

It is evident that the selection is systematically shifted towards the final part of the step.
This is not a problem when only one bias is changed also because the crop of starting and final period in the selection of scientific data was implemented in the data analysis.
It causes an actual wrong selection when both the biases are changed and the delay in the housekeeping recording increases.
Some further study is needed to avoid this problem in the future runs.
Another main uncertainty, requiring futher study is the reference load temperature to be used for this test.
The HFI thermometers close to the LFI reference loads are only sensitive below about 6.5 K, so that a different sensor has been used as reference during the higher temperature steps.
Even though the tuning procedure is a relative measurement and this systematic error affects each point at the same level, an assessment of the uncertainty in the absolute noise temperature evaluation will be performed in detail, to have better estimates for the in flight verification.

8 CONCLUSIONS

The ACA tuning verification has been performed successfully during LFI TV campaign. The new test strategy (matrix tuning), allowed to scan a larger range of biases where optimal values could be found.
The data analysis allowed a quick and prompt selection of optimal biases.
Some new solutions in the harmonization between data acquisition and data analysis have to be detailed in order to avoid residual uncertainties for the best exploitation of this tuning strategy during CPV phase.