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**TITLE:** # Planck-LFI CPV: Phase Switch tuning (P_PVP_LFI_0004_01)

**DOC. TYPE:** **Test Report**

**PROJECT REF.:** **PL-LFI-PST-RP-083** **PAGE: I of V, 43**

**ISSUE/REV.:** **1.0**

| | | |
|---|---|---|
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# CHANGE RECORD

| Issue | Date | Sheet | Description of Change | Release |
|---|---|---|---|---|
| Draft | 15 Jun. 09 | All | First draft issue | == |
| 1.0 | 05 Oct. 09 | All | First Issue | CPV completion Review Meeting |
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# 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 |

# APPLICABLE AND REFERENCE DOCUMENTS

## 1.1 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

[AD7] Testing plan of the LFI instrument during the Planck Commissioning and CPV phase, PL-LFI-PST-PL-043 (4.2)

## 1.2 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] Villa, F. (2008), Planck LFI TV Test @ CSL: Phase Switch Matrix Tuning Guide.

## Introduction

This document describes the activities performed during the first phase switch tuning test performed during CPV.

The objective of this test is to find the optimal bias currents to the front-end phase switches that balance the wave amplitude in the two phase switch states. An optimal balance has an impact on the receiver isolation, therefore the test was performed before the tuning of the front-end modules amplifiers. The test was performed only on 30 and 44GHz RCAs as planned. Details of the test concept are reported in [RD4].

# Test Execution

## 1.3 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 |

## 1.4 Pass-fail criteria, verification matrix

| | | | | | | |
|---|---|---|---|---|---|---|
| **CPV** | **P_PVP_LFI_0004_01** | | | | | |
| **June, 17 2009 21:30z** | **DoY 168** | **OD 35** | | | | |
| **Duration** | **9:59:46** | | | | | |
| **Test name:** | **P/S tuning verification** | | | | | |
| **Test objectives:** | The main objective of the test is to perform a verification of the balance of the two diodes in each PS of each FEM unit. The test is performed only on the 33 and 44 GHz RCAs, as on the 70 GHz radiometers the currents are maximized in order to reduce the transition time of the output signal between the two states of the PS. In principle the nominal bias condition derived from the RAA tests shall be the optimal one. The test is performed on each ACA, biasing each channel separately. For this purpose the ACA coupled with the one under test is switched-off. The<br>phase switch is activated, thus producing two different output signal traces for the radiometer under test when the PS is not balanced. The balancing philosophy is described in the procedure | | | | | |
| **Verification matrix** | | | | | | |
| **Check** | **Passed?** | | | **Recovered?** | | |
| | **Yes** | **No** | **Notes** | **Yes** | **No** | |
| No unexpected events packets | (green) | | | | | |
| TC procedure | (green) | | | | | |
| Every P/S is responding to bias stimuli as expected | (green) | | | | | |
| Correct biases for P/S balancing Applied and Checked | (green) | | | | | |
| No unexpected features | (green) | | | | | |
| Data saved and stored at DPC | (green) | | | | | |

## 1.5 Procedure/ Test sequence and environmental conditions

Figure 1 reports the top level procedure of the test; the complete test procedure and related check list is reported in appendix A. The PSW tuning was performed on RCAs 24 and 25 firstly, then was performed on RCAs 26 and 27, then was performend on RCA 28. The loop over the bias currents I1 and I2 was set according to the grid definition as reported in .

The Figure 3, Figure 4, Figure 5, Figure 6, and Figure 7 show the grid applied during CPV with respect the CSL grids (coloured filled contour plots).

| Description | START REF. | DURATION | RCA |
|---|---|---|---|
| P/S Tuning (UM section 13.1.2.6) | 0.00.00 | 0.00.00 | |
| **RCA 24 and 25** | **0.00.00** | **0.00.00** | **24,25** |
| Perform I1 vs I2 tuning for ACA2 | 0.00.18 | 0.44.42 | 24,25-2 |
| Perform I1 vs I2 tuning for ACA1 | 0.45.18 | 0.44.42 | 24,25-1 |
| Perform I1 vs I2 tuning for ACA4 | 1.30.18 | 0.44.42 | 24,25-4 |
| Perform I1 vs I2 tuning for ACA3 | 2.15.18 | 0.44.42 | 24,25-3 |
| **RCA 26 and 27** | **3.00.28** | **0.00.00** | **26,27** |
| Perform I1 vs I2 tuning for ACA2 | 3.00.34 | 0.45.26 | 26,27-2 |
| Perform I1 vs I2 tuning for ACA1 | 3.46.18 | 0.44.42 | 26,27-1 |
| Perform I1 vs I2 tuning for ACA4 | 4.31.18 | 0.44.42 | 26,27-4 |
| Perform I1 vs I2 tuning for ACA3 | 5.16.18 | 0.44.42 | 26,27-3 |
| **RCA 28** | **6.01.12** | **0.00.00** | **28-1** |
| Perform I1 vs I2 tuning for ACA2 | 6.01.18 | 0.44.42 | 28-2 |
| Perform I1 vs I2 tuning for ACA1 | 6.46.42 | 0.45.18 | 28-1 |
| Perform I1 vs I2 tuning for ACA4 | 7.32.42 | 0.45.18 | 28-4 |
| Perform I1 vs I2 tuning for ACA3 | 8.18.18 | 0.44.42 | 28-3 |

*Figure 1: Top level pocedure of the PSW tuning test.*

| RCA # | ACA ID | SCOS Parameter | Start Values | | Stop Values | | Step | |
|---|---|---|---|---|---|---|---|---|
| | | | I1 | I2 | I1 | I2 | I1 | I2 |
| | | | DEC | DEC | DEC | DEC | DEC | DEC |
| | | | | | | | | |
| CH27 | M1 | LP001320 | 128 | 130 | 228 | 230 | 11 | 11 |
| | M2 | LP002320 | 94 | 155 | 194 | 255 | 11 | 11 |
| | S1 | LP003320 | 97 | 134 | 197 | 234 | 11 | 11 |
| | S2 | LP004320 | 78 | 155 | 178 | 255 | 11 | 11 |
| | | | | | | | | |
| CH24 | M2 | LP005320 | 57 | 155 | 157 | 255 | 11 | 11 |
| | M1 | LP006320 | 78 | 155 | 178 | 255 | 11 | 11 |
| | S2 | LP007320 | 56 | 155 | 156 | 255 | 11 | 11 |
| | S1 | LP008320 | 54 | 155 | 154 | 255 | 11 | 11 |
| | | | | | | | | |
| CH25 | M1 | LP021320 | 104 | 155 | 204 | 255 | 11 | 11 |
| | M2 | LP022320 | 49 | 155 | 149 | 255 | 11 | 11 |
| | S1 | LP023320 | 49 | 155 | 149 | 255 | 11 | 11 |
| | S2 | LP024320 | 89 | 155 | 189 | 255 | 11 | 11 |
| | | | | | | | | |
| CH28 | M1 | LP025320 | 100 | 130 | 200 | 230 | 11 | 11 |
| | M2 | LP026320 | 67 | 138 | 167 | 238 | 11 | 11 |
| | S1 | LP027320 | 77 | 142 | 177 | 242 | 11 | 11 |
| | S2 | LP028320 | 53 | 125 | 153 | 225 | 11 | 11 |
| | | | | | | | | |
| CH26 | M2 | LP041320 | 93 | 155 | 193 | 255 | 11 | 11 |
| | M1 | LP042320 | 48 | 155 | 148 | 255 | 11 | 11 |
| | S2 | LP043320 | 53 | 155 | 153 | 255 | 11 | 11 |
| | S1 | LP044320 | 105 | 155 | 205 | 255 | 11 | 11 |

*Figure 2: Grid definiton of bias currents. The start, stop, and number of steps are reported.*

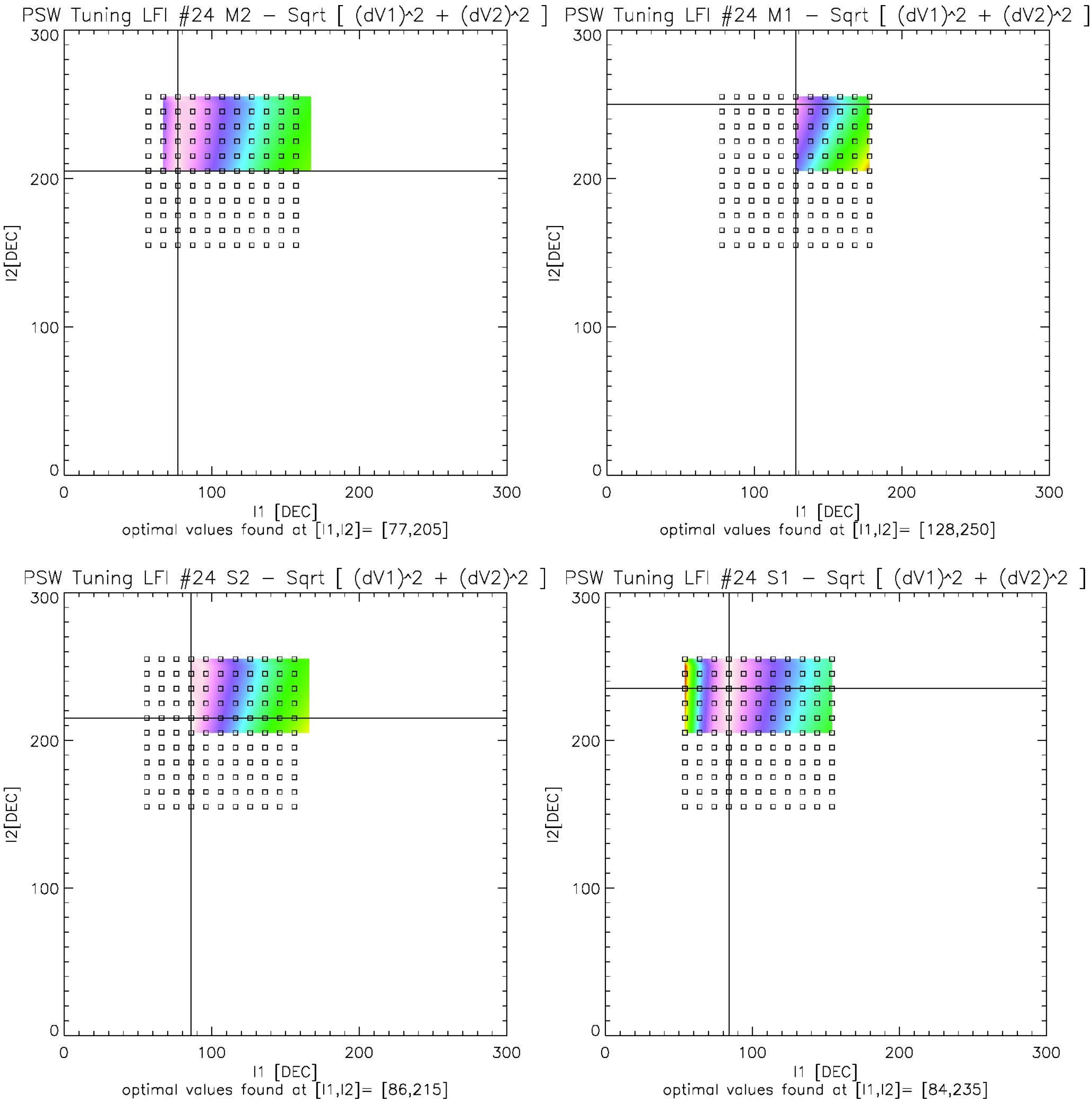



*Figure 3: RCA24 Grid Definition. The coloured contour plot area is the CSL phase switch tuning test. The black grid is the new grid definition for the CPV.*

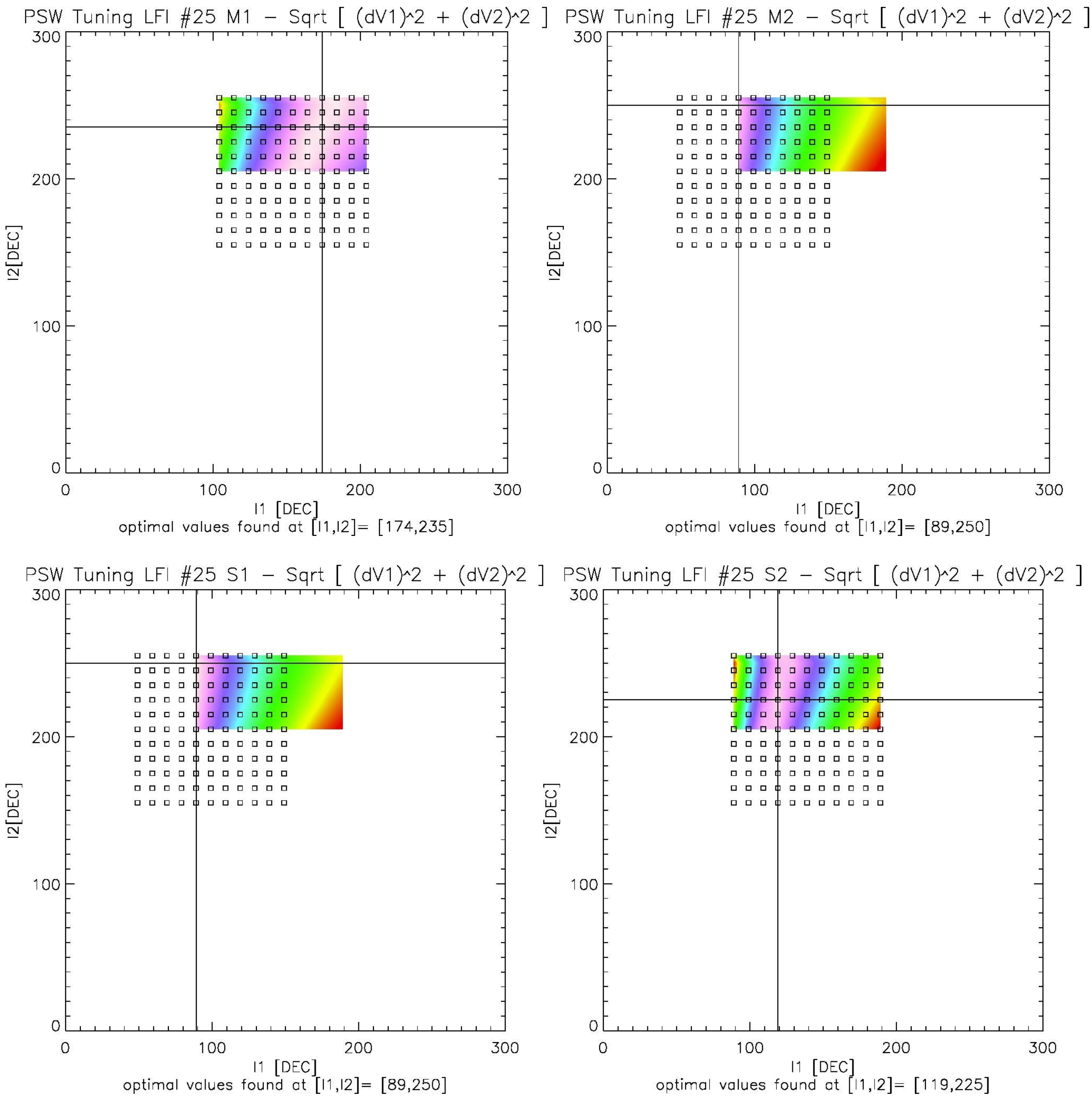



*Figure 4: RCA25 Grid Definition. The coloured contour plot area is the CSL phase switch tuning test. The black grid is the new grid definition for the CPV.*

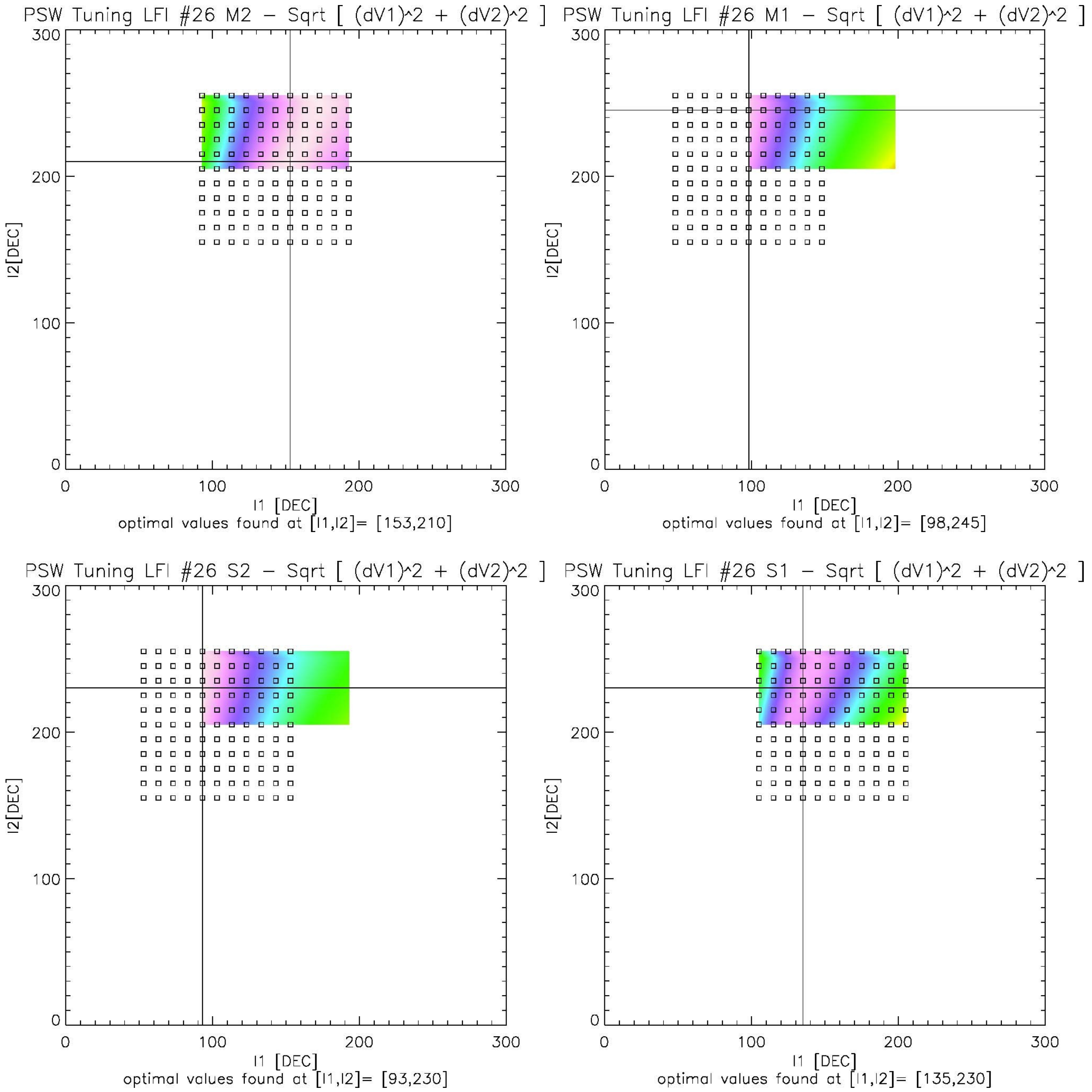



*Figure 5: RCA26 Grid Definition. The coloured contour plot area is the CSL phase switch tuning test. The black grid is the new grid definition for the CPV.*

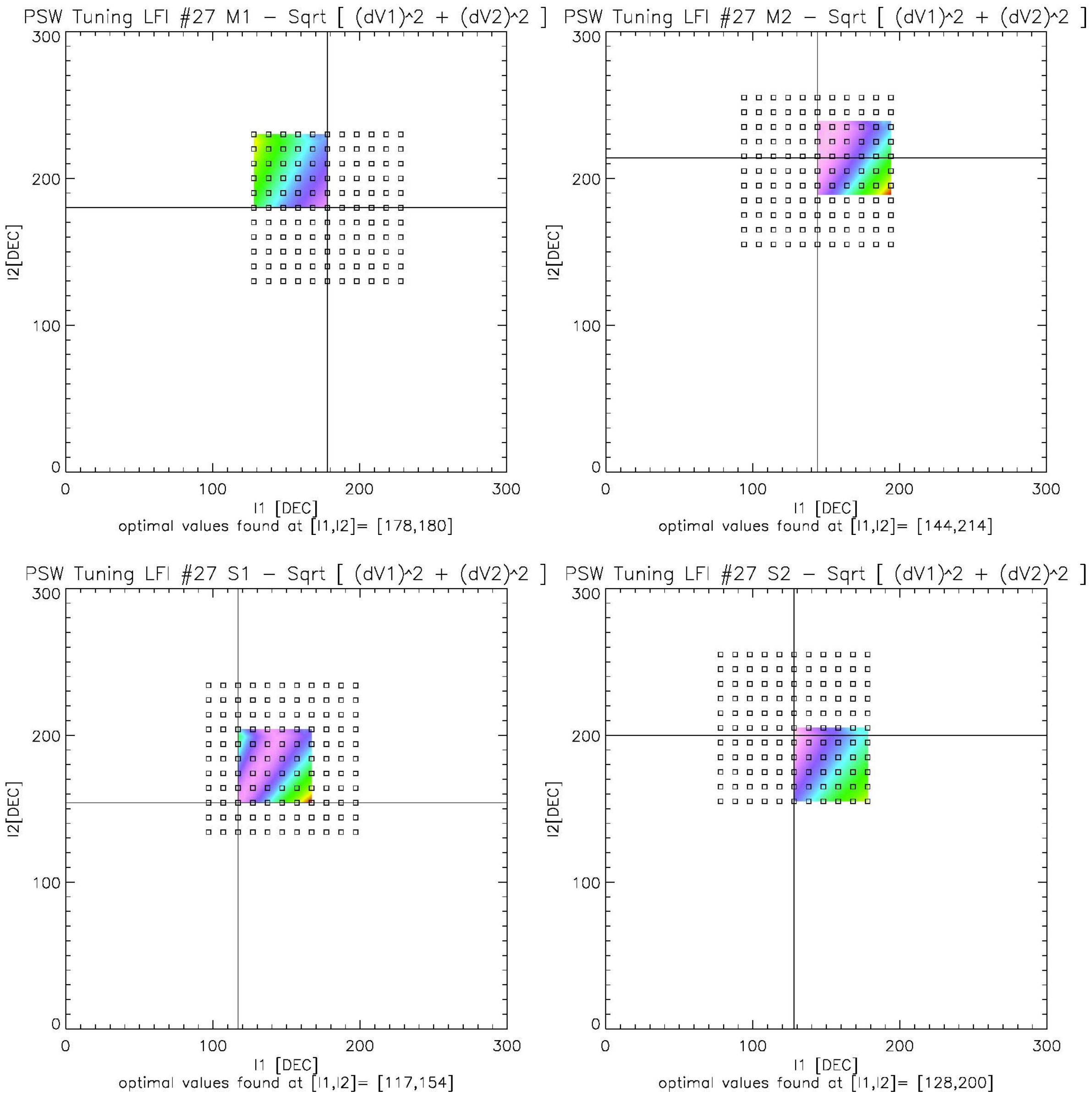



*Figure 6: RCA27 Grid Definition. The coloured contour plot area is the CSL phase switch tuning test. The black grid is the new grid definition for the CPV.*

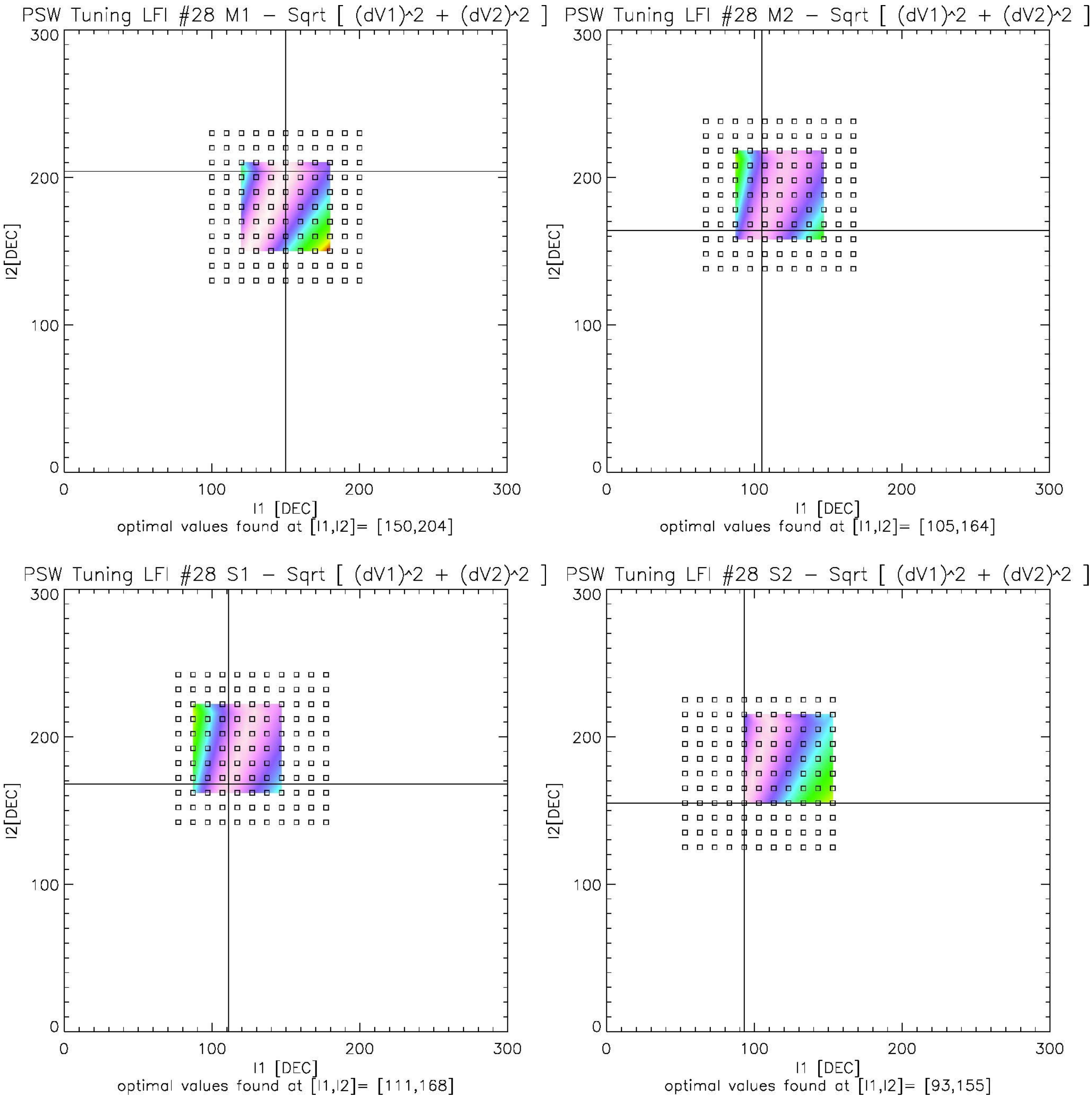



*Figure 7: RCA28 Grid Definition. The coloured contour plot area is the CSL phase switch tuning test. The black grid is the new grid definition for the CPV.*

The test started at 2009-06-17T21:30:00 UTC and ended at 2009-06-18T07:29:46 UTC (OD35). No problems were found. A snap shot of the test execution is reported in Figure 9 where the phase switch bias currents are plotted as function of time. The corresponding radiometer outputs are plotted in figure Figure 9 and Figure 10 for the 30GHz and 44GHz RCAs respectively.

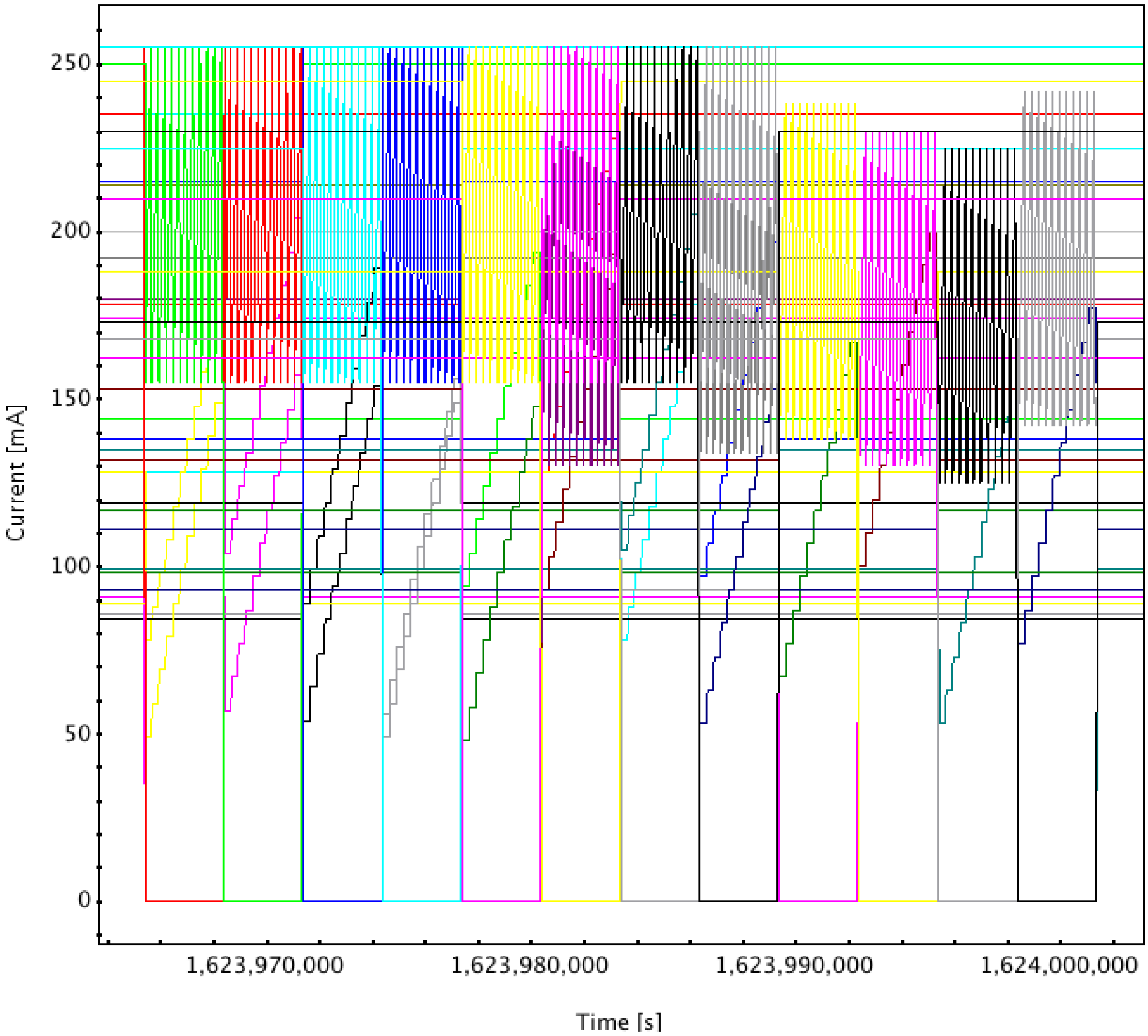



*Figure 8. I1 and I2 current values as plotted in pegaso_view*

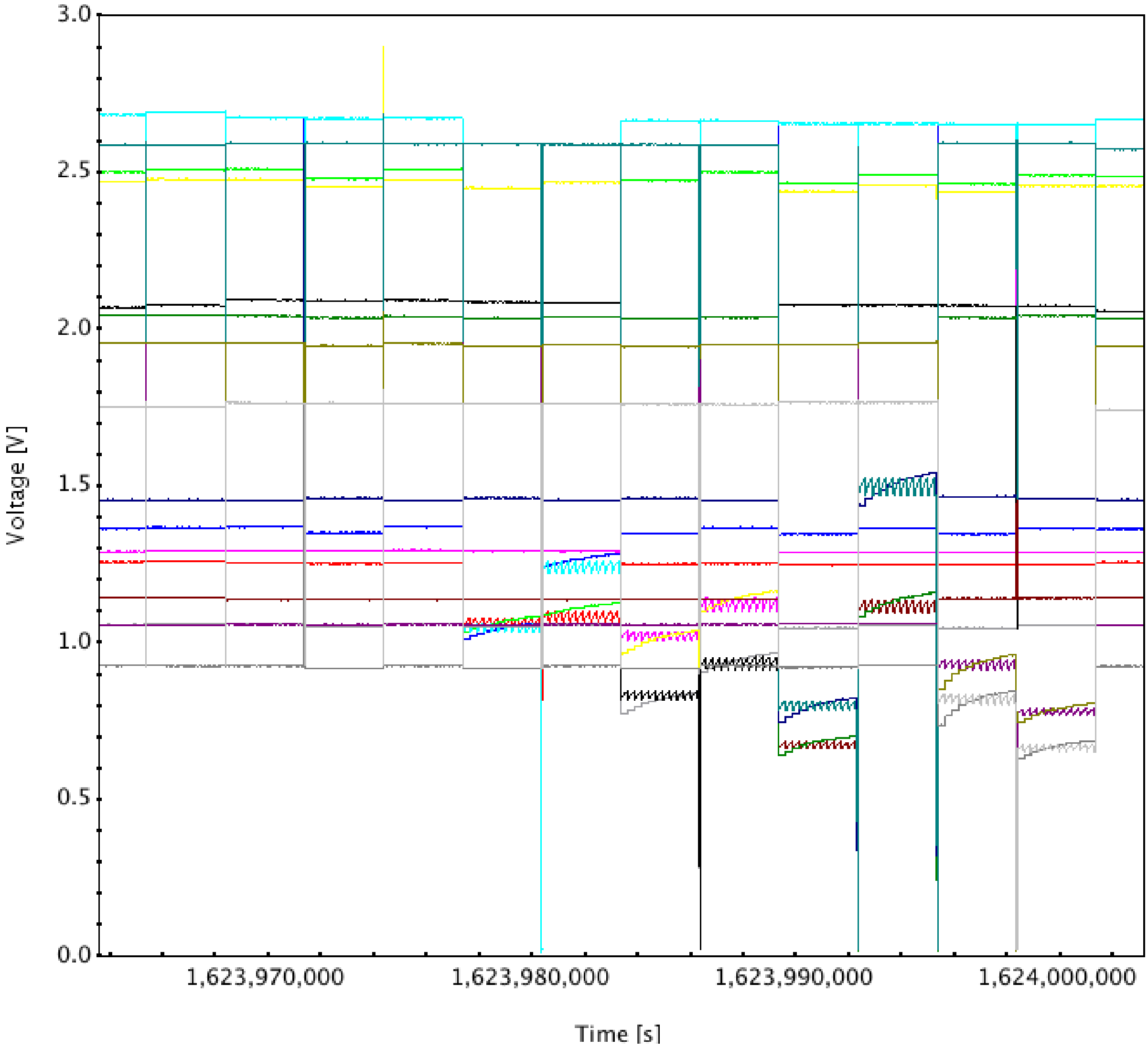



*Figure 9. Output radiometer voltages as plotted in pegaso_view for the 30 GHz RCA phase switches tuning*

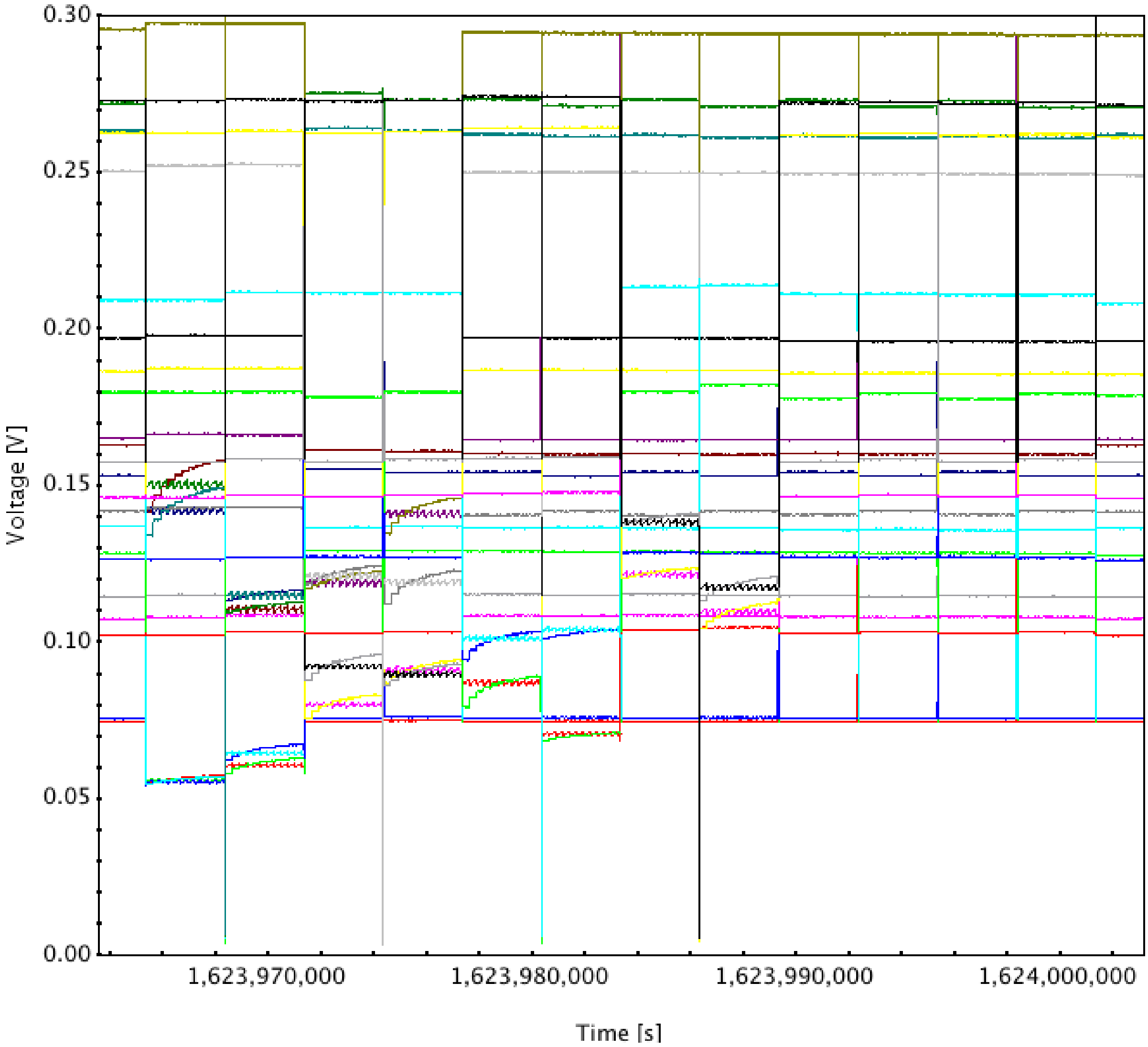



*Figure 10. Output radiometer voltages as plotted in pegaso_view for the 30 GHz RCA phase switches tuning*

## Data analysis

The data analysis was performed in LIFE environment with the following IDL script, namely `cpv_psw_script.pro`, as reported hereafter. It uses `pegaso_tune_phase_switch_currents()` pegaso routine version 1.9.
The analysis proceeded in three steps described in the following sections.

### 1.6 Step 1

Execution of the pegaso routines to carry out, for each phase switch, the surfaces Z=(I1,I2), where Z can be the following quantities:

| | |
|---|---|
| $V_1^{(even)}$ : | average over the time window of the even samples of the signal at first detector |
| $V_1^{(odd)}$ : | average over the time window of the odd samples of the signal at first detector |
| $\Delta V_1$ | defined as $\Delta V_1 = V_1^{\text{even}} - V_1^{\text{odd}}$ |
| $V_1^{(even)}$ : | average over the time window of the even samples of the signal at second detector |
| $V_1^{(odd)}$ : | average over the time window of the odd samples of the signal at second detector |
| $\Delta V_2$: | defined as $\Delta V_2 = V_2^{\text{even}} - V_2^{\text{odd}}$ |
| $\Delta V$: | defined as $\Delta V = \sqrt{\Delta V_1^2 + \Delta V_2^2}$ |

For each phase the following data files were created:

`CPV_PSW_tuning_raw_LFIXX_ID.csv`
(for example: `CPV_PSW_tuning_raw_LFI24_M1.csv`)

| I1 | I2 | V1even | V1odd | DV1 | V2even | V2odd | DV2 | DV | T0 | T1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 128 | 250 | 7.46E-02 | 1.28E-01 | 5.34E-02 | 7.53E-02 | 1.36E-01 | 6.11E-02 | 8.11E-02 | 1623963464 | 1623965420 |
| 78 | 155 | 5.50E-02 | 5.54E-02 | 3.41E-04 | 5.49E-02 | 5.47E-02 | 2.03E-04 | 3.97E-04 | 1623965421 | 1623965442 |
| 78 | 165 | 5.50E-02 | 5.55E-02 | 4.57E-04 | 5.50E-02 | 5.47E-02 | 3.24E-04 | 5.60E-04 | 1623965443 | 1623965464 |
| 78 | 175 | 5.50E-02 | 5.56E-02 | 5.58E-04 | 5.52E-02 | 5.47E-02 | 4.24E-04 | 7.01E-04 | 1623965465 | 1623965486 |
| 78 | 185 | 5.50E-02 | 5.57E-02 | 6.57E-04 | 5.52E-02 | 5.47E-02 | 5.17E-04 | 8.36E-04 | 1623965487 | 1623965508 |
| 78 | 195 | 5.50E-02 | 5.57E-02 | 7.54E-04 | 5.53E-02 | 5.47E-02 | 6.01E-04 | 9.64E-04 | 1623965509 | 1623965530 |
| 78 | 205 | 5.50E-02 | 5.58E-02 | 8.37E-04 | 5.54E-02 | 5.47E-02 | 6.75E-04 | 1.08E-03 | 1623965531 | 1623965552 |
| 78 | 215 | 5.50E-02 | 5.59E-02 | 9.14E-04 | 5.54E-02 | 5.47E-02 | 7.48E-04 | 1.18E-03 | 1623965553 | 1623965574 |
| 78 | 225 | 5.50E-02 | 5.60E-02 | 9.86E-04 | 5.55E-02 | 5.47E-02 | 8.15E-04 | 1.28E-03 | 1623965575 | 1623965596 |
| 78 | 235 | 5.50E-02 | 5.60E-02 | 1.05E-03 | 5.56E-02 | 5.47E-02 | 8.75E-04 | 1.36E-03 | 1623965597 | 1623965618 |
| 78 | 245 | 5.50E-02 | 5.61E-02 | 1.10E-03 | 5.56E-02 | 5.47E-02 | 9.29E-04 | 1.44E-03 | 1623965619 | 1623965639 |
| 78 | 255 | 5.50E-02 | 5.61E-02 | 1.15E-03 | 5.57E-02 | 5.47E-02 | 9.83E-04 | 1.51E-03 | 1623965640 | 1623965662 |
| 78 | 155 | 5.50E-02 | 5.53E-02 | 3.54E-04 | 5.49E-02 | 5.47E-02 | 2.12E-04 | 4.13E-04 | 1623965663 | 1623965685 |
| 88 | 155 | 5.55E-02 | 5.53E-02 | 1.34E-04 | 5.49E-02 | 5.52E-02 | 2.66E-04 | 2.97E-04 | 1623965686 | 1623965707 |
| 88 | 165 | 5.55E-02 | 5.55E-02 | 2.12E-05 | 5.50E-02 | 5.52E-02 | 1.49E-04 | 1.51E-04 | 1623965708 | 1623965729 |

This file contains all the current changes within the selected time window. This means that also the changes in currents applied during the switching on/off of the ACAs are recorded in this file. The columns reports the output of each diode (even and odd samples and difference), as well as the quadratic difference and the time interval for each current change.

`CPV_PSW_tuning_LFIXX_ID.csv`
(for example `CPV_PSW_tuning_LFI24_M1.csv`)

| I1 | I2 | V1even | V1odd | DV1 | V2even | V2odd | DV2 | DV |
|---|---|---|---|---|---|---|---|---|
| 78 | 155 | 5.50E-02 | 5.54E-02 | 3.41E-04 | 5.49E-02 | 5.47E-02 | 2.03E-04 | 3.97E-04 |
| 78 | 165 | 5.50E-02 | 5.55E-02 | 4.57E-04 | 5.50E-02 | 5.47E-02 | 3.24E-04 | 5.60E-04 |
| 78 | 175 | 5.50E-02 | 5.56E-02 | 5.58E-04 | 5.52E-02 | 5.47E-02 | 4.24E-04 | 7.01E-04 |
| 78 | 185 | 5.50E-02 | 5.57E-02 | 6.57E-04 | 5.52E-02 | 5.47E-02 | 5.17E-04 | 8.36E-04 |
| 78 | 195 | 5.50E-02 | 5.57E-02 | 7.54E-04 | 5.53E-02 | 5.47E-02 | 6.01E-04 | 9.64E-04 |
| 78 | 205 | 5.50E-02 | 5.58E-02 | 8.37E-04 | 5.54E-02 | 5.47E-02 | 6.75E-04 | 1.08E-03 |
| 78 | 215 | 5.50E-02 | 5.59E-02 | 9.14E-04 | 5.54E-02 | 5.47E-02 | 7.48E-04 | 1.18E-03 |
| 78 | 225 | 5.50E-02 | 5.60E-02 | 9.86E-04 | 5.55E-02 | 5.47E-02 | 8.15E-04 | 1.28E-03 |
| 78 | 235 | 5.50E-02 | 5.60E-02 | 1.05E-03 | 5.56E-02 | 5.47E-02 | 8.75E-04 | 1.36E-03 |
| 78 | 245 | 5.50E-02 | 5.61E-02 | 1.10E-03 | 5.56E-02 | 5.47E-02 | 9.29E-04 | 1.44E-03 |
| 78 | 255 | 5.50E-02 | 5.61E-02 | 1.15E-03 | 5.57E-02 | 5.47E-02 | 9.83E-04 | 1.51E-03 |
| 88 | 155 | 5.55E-02 | 5.53E-02 | 1.34E-04 | 5.49E-02 | 5.52E-02 | 2.66E-04 | 2.97E-04 |
| 88 | 165 | 5.55E-02 | 5.55E-02 | 2.12E-05 | 5.50E-02 | 5.52E-02 | 1.49E-04 | 1.51E-04 |

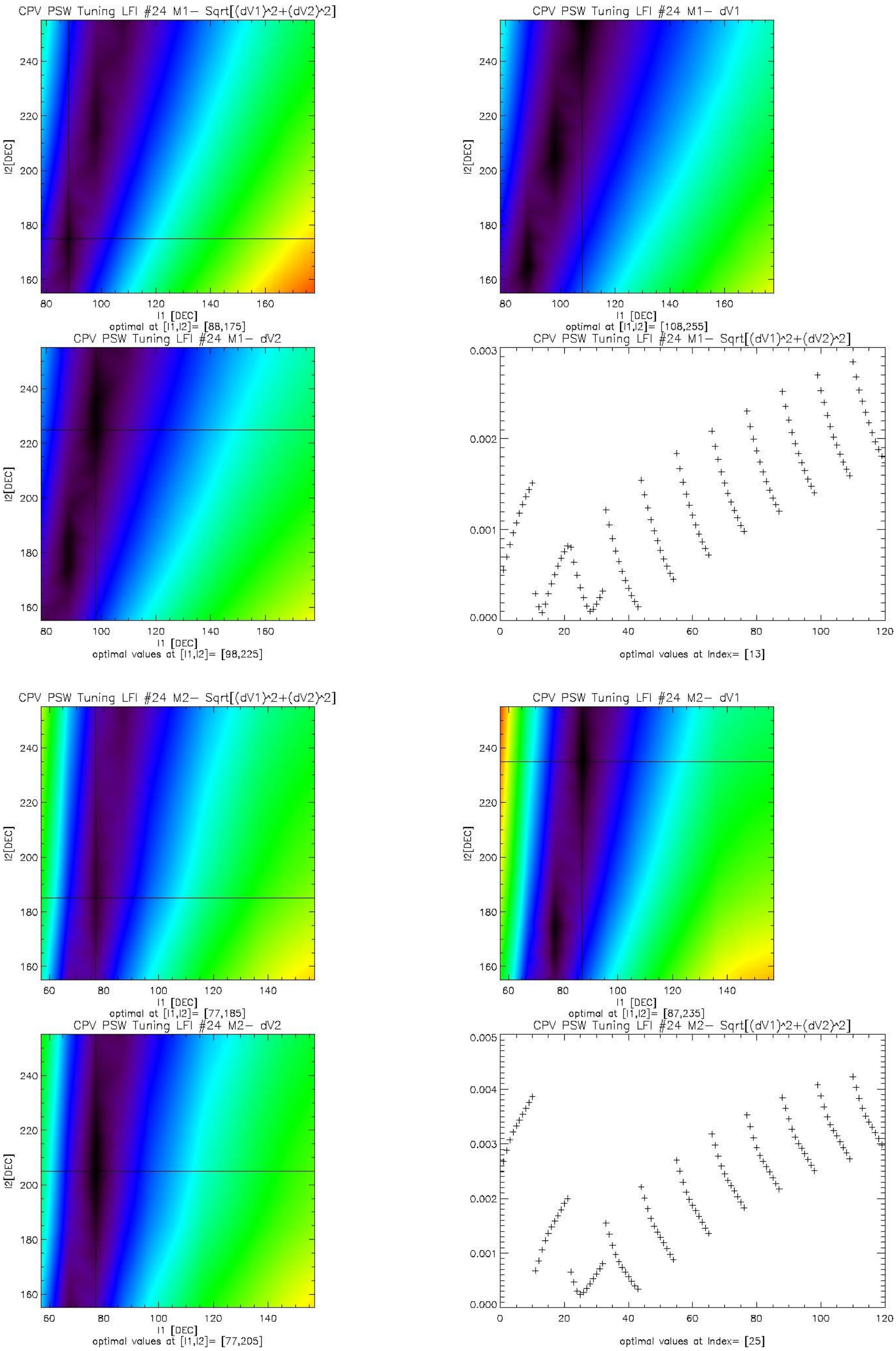
this file contains the same information of the above file but for 121 points (11x11) for each phase switch as required by the procedure. The time information has not recorded in this file since it was created mainly for plotting the results. The graphical output is stored in the following files:

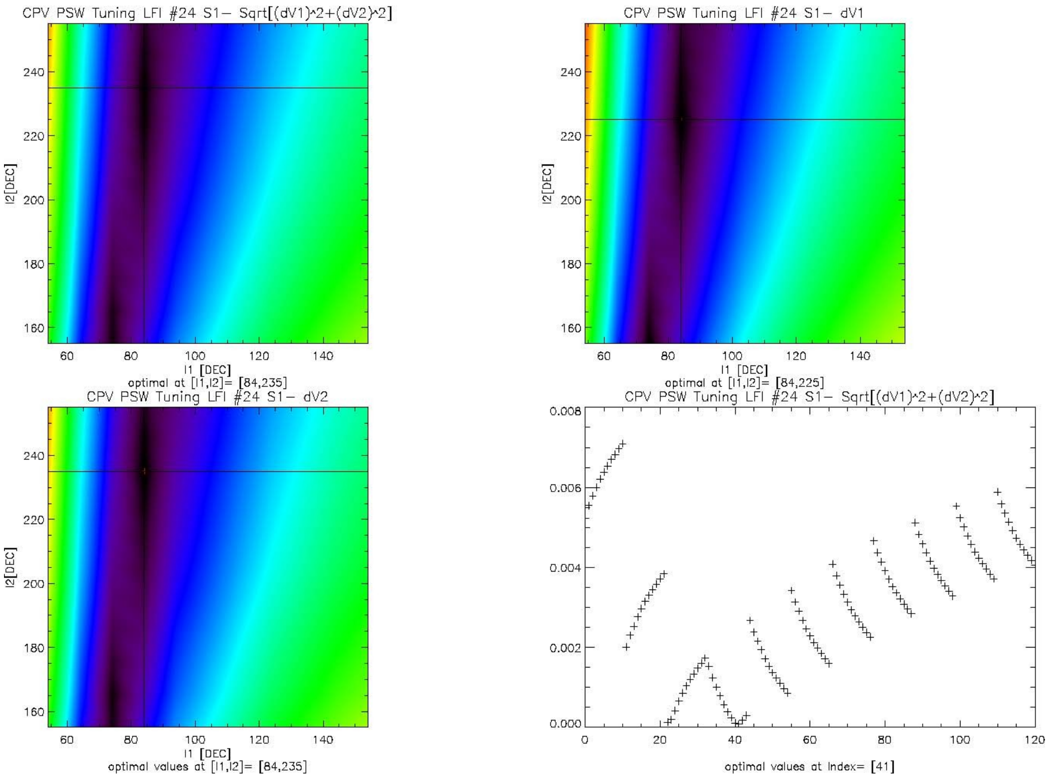
`CPV_PSW_tuning_LFI24_M1.ps`
containing the contour plot graphical output of $\Delta V$, $\Delta V_1$, and $\Delta V_2$.

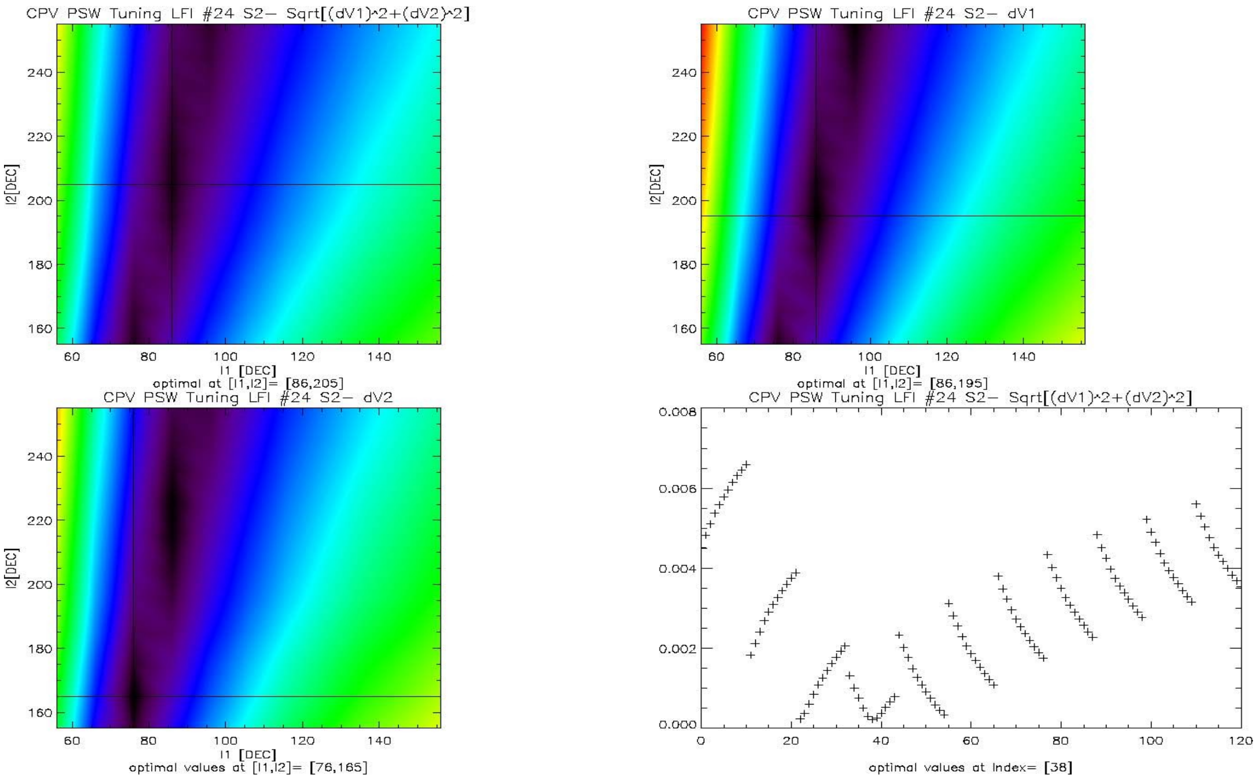
`CPV_PSW_tuning_LFI24_M1_surf.ps`
containing the surface plot graphical output of $\Delta V$, $\Delta V_1$, and $\Delta V_2$.

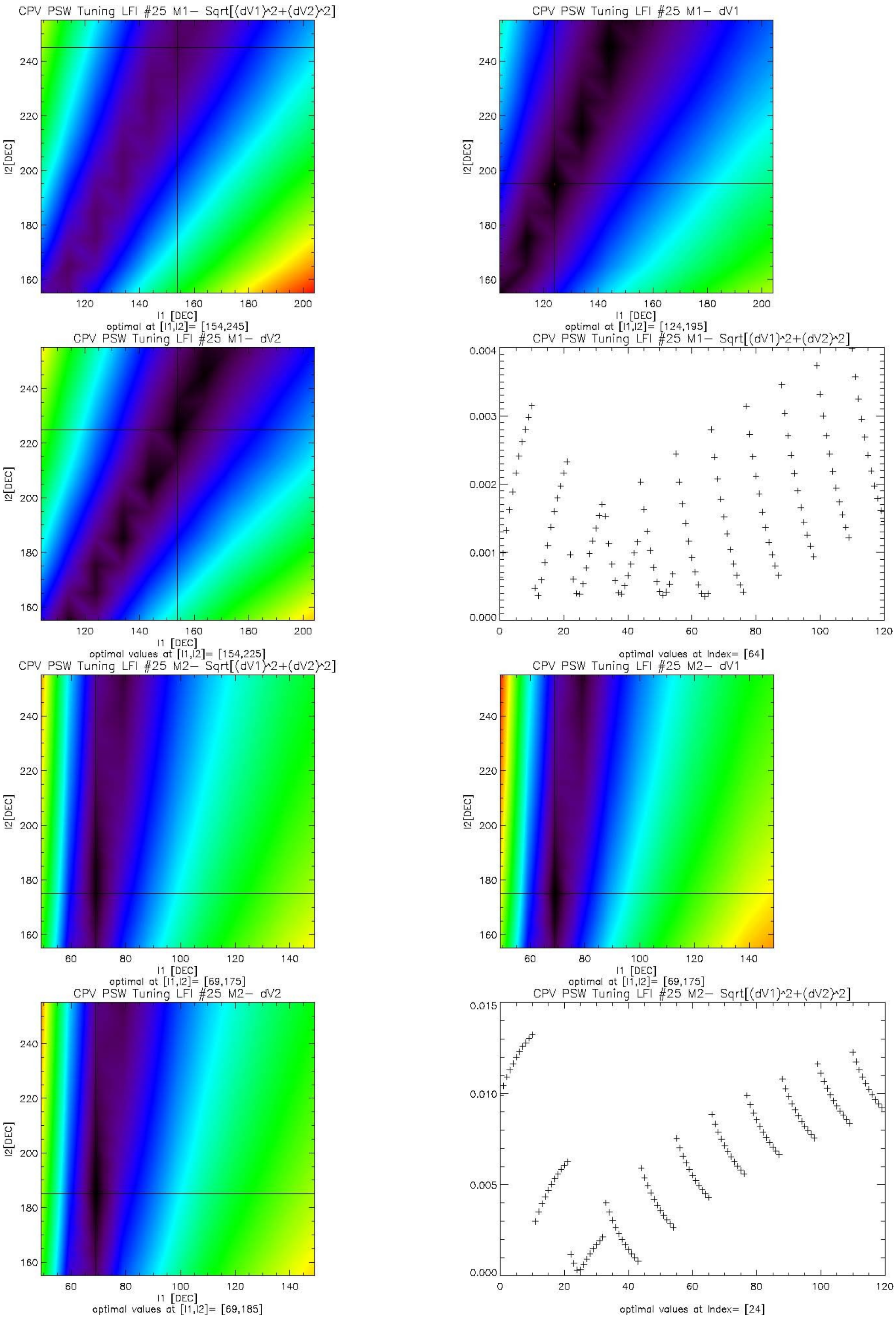
In addition in both files a plot of $\Delta V$ is reported to check the regularity of the test and to prevent any problems in selection as occurred during the CSL test analysis.

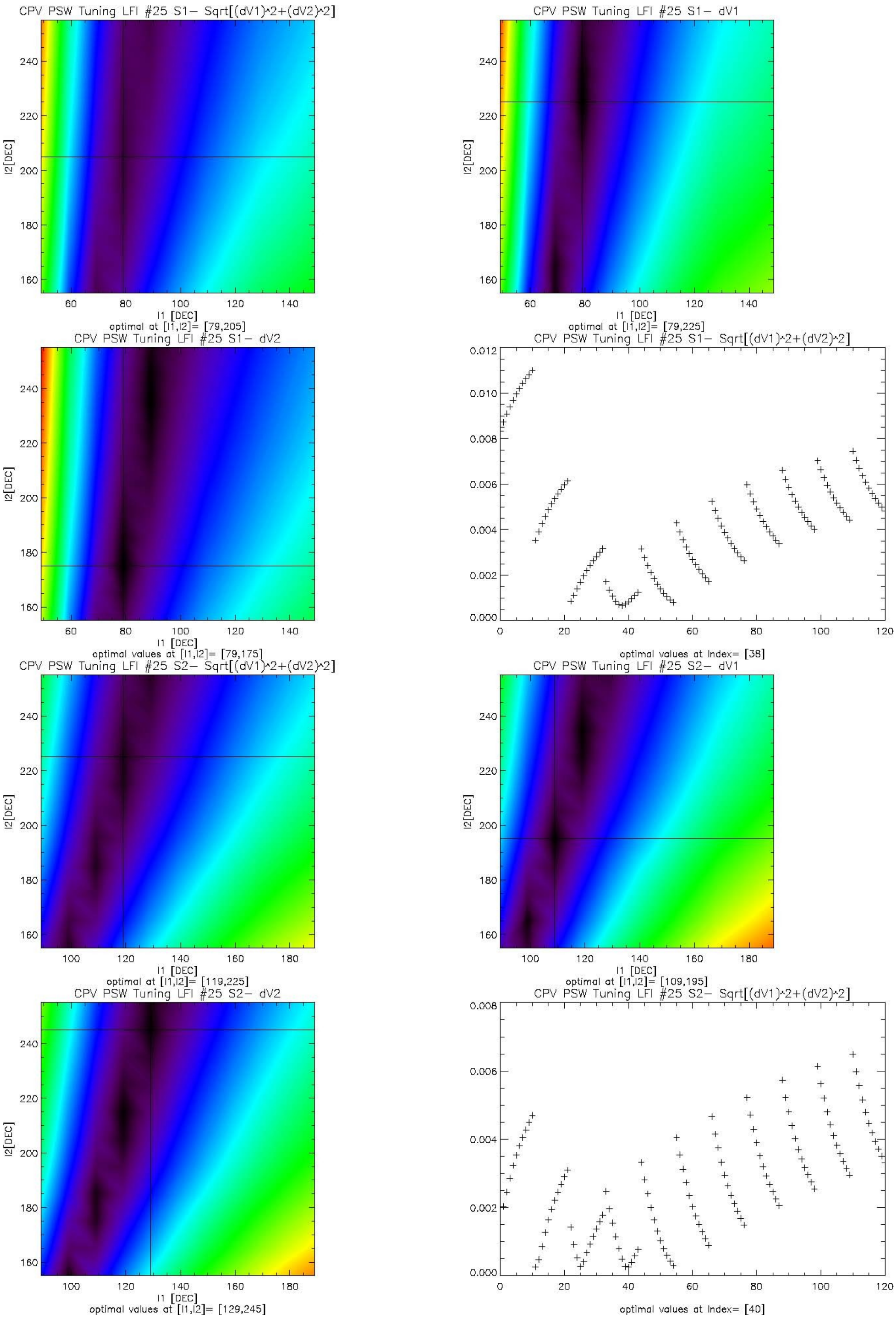
The contour plots are reported in the figures in the following pages. For each plot the local minimum has been found and reported.

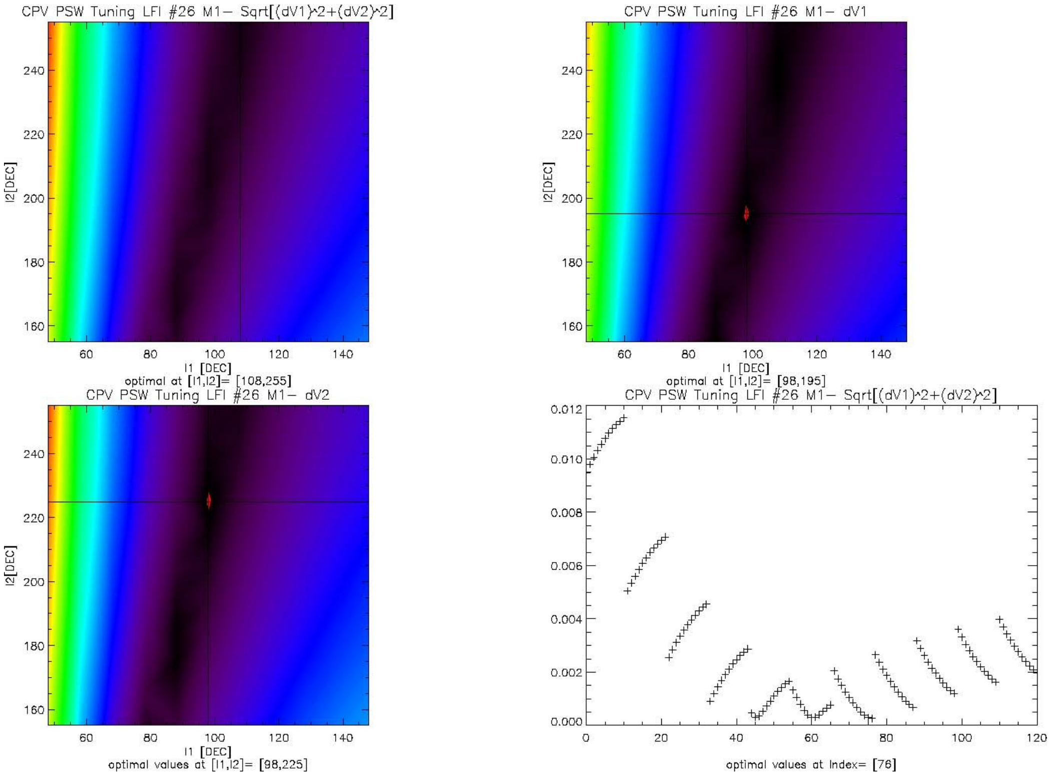

CPV PSW Tuning LFI #24 M1– Sqrt[(dV1)^2+(dV2)^2]
optimal at [I1,I2]= [88,175]
CPV PSW Tuning LFI #24 M1– dV1
optimal at [I1,I2]= [108,255]
CPV PSW Tuning LFI #24 M1– dV2
optimal values at [I1,I2]= [98,225]
CPV PSW Tuning LFI #24 M1– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [13]
CPV PSW Tuning LFI #24 M2– Sqrt[(dV1)^2+(dV2)^2]
optimal at [I1,I2]= [77,185]
CPV PSW Tuning LFI #24 M2– dV1
optimal at [I1,I2]= [87,235]
CPV PSW Tuning LFI #24 M2– dV2
optimal values at [I1,I2]= [77,205]
CPV PSW Tuning LFI #24 M2– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [25]
I1 [DEC]
I2[DEC]

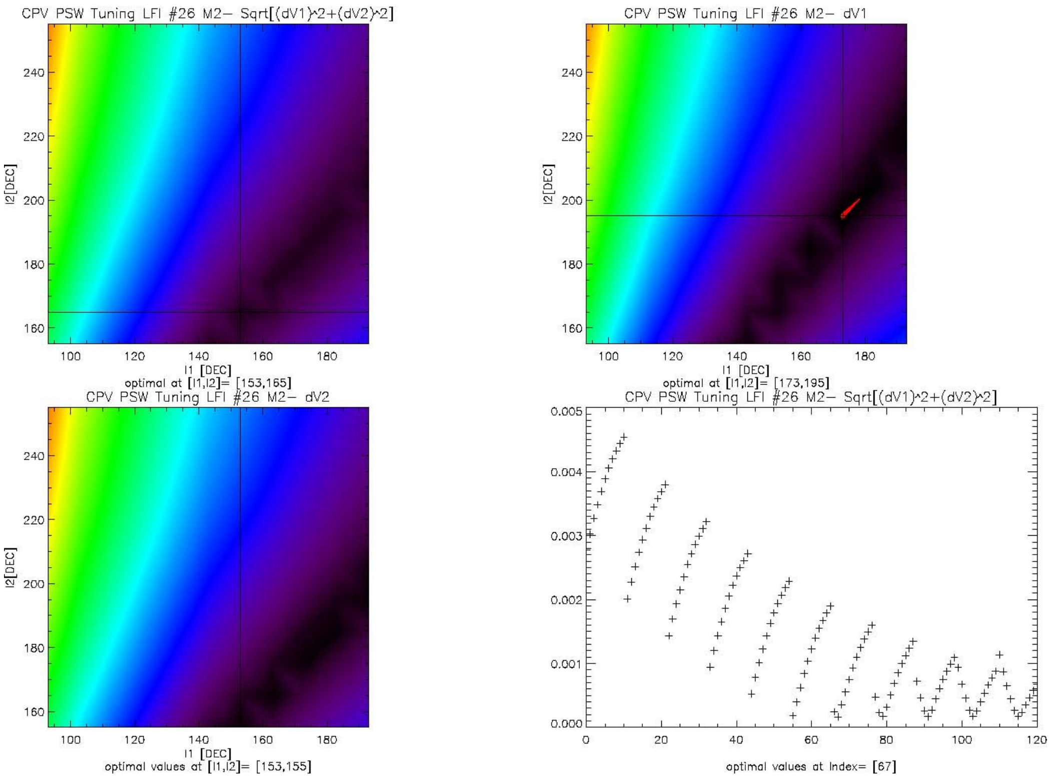

CPV PSW Tuning LFI #24 S1– Sqrt[(dV1)^2+(dV2)^2]
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [84,235]
CPV PSW Tuning LFI #24 S1– dV1
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [84,225]
CPV PSW Tuning LFI #24 S1– dV2
I2[DEC]
I1 [DEC]
optimal values at [I1,I2]= [84,235]
CPV PSW Tuning LFI #24 S1– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [41]

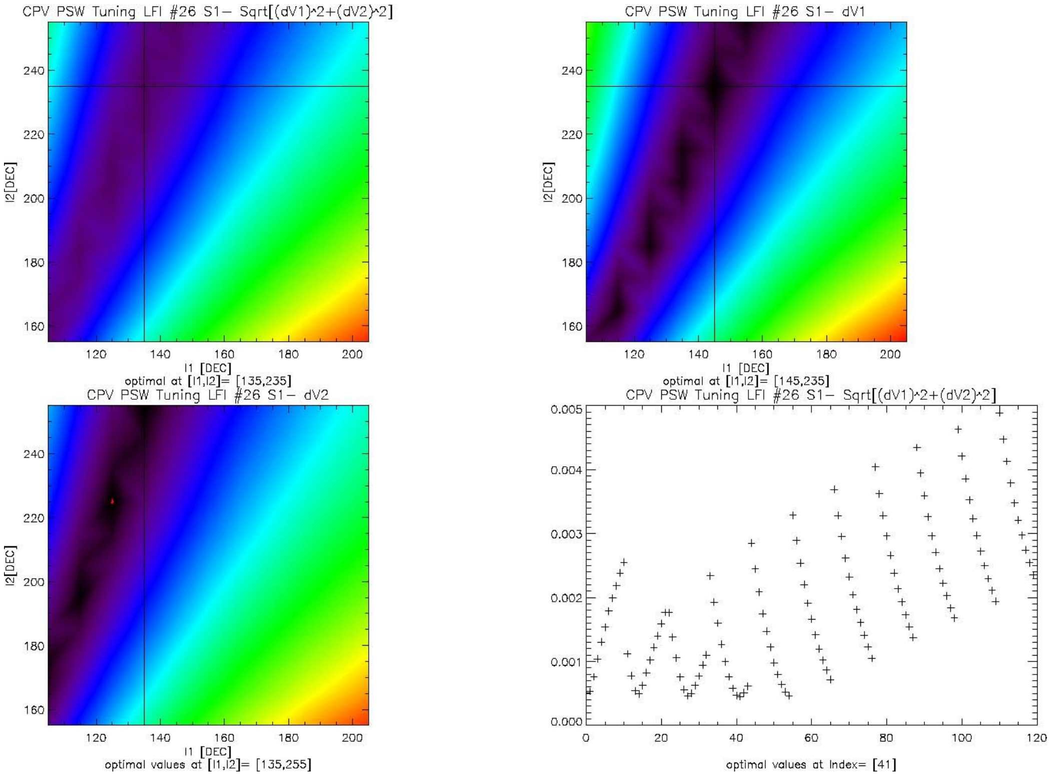

CPV PSW Tuning LFI #24 S2– Sqrt[(dV1)^2+(dV2)^2]
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [86,205]
CPV PSW Tuning LFI #24 S2– dV1
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [86,195]
CPV PSW Tuning LFI #24 S2– dV2
I2[DEC]
I1 [DEC]
optimal values at [I1,I2]= [76,165]
CPV PSW Tuning LFI #24 S2– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [38]

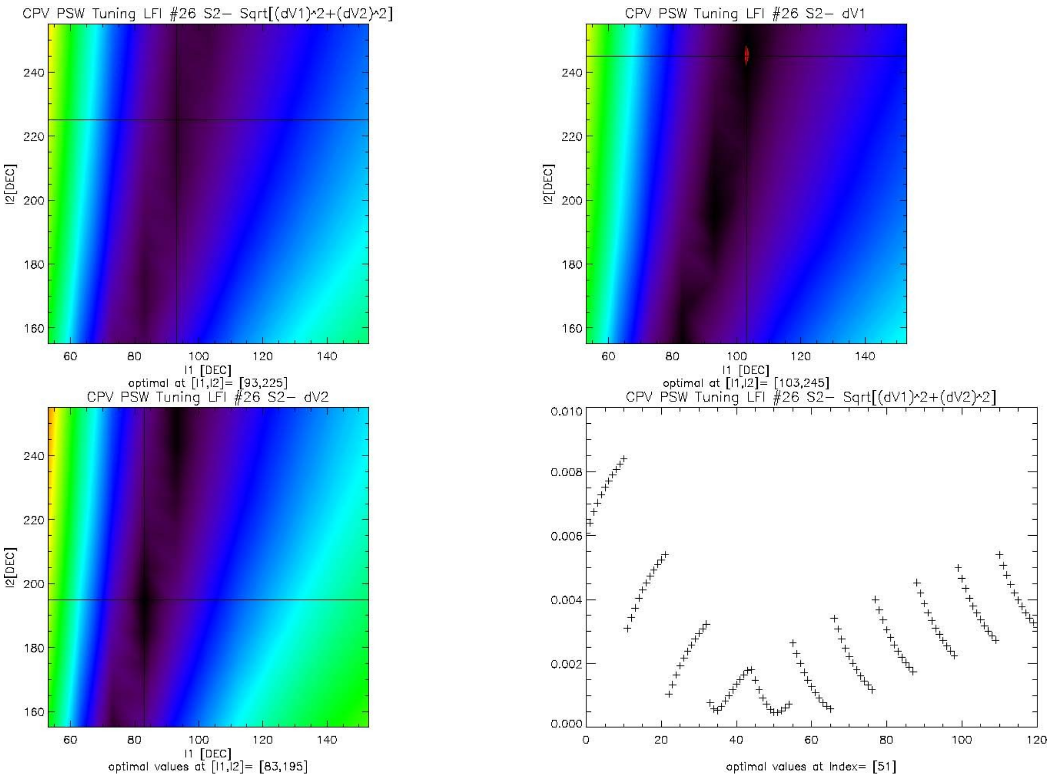

CPV PSW Tuning LFI #25 M1– Sqrt[(dV1)^2+(dV2)^2]
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [154,245]
CPV PSW Tuning LFI #25 M1– dV1
optimal at [I1,I2]= [124,195]
CPV PSW Tuning LFI #25 M1– dV2
optimal values at [I1,I2]= [154,225]
CPV PSW Tuning LFI #25 M1– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [64]
CPV PSW Tuning LFI #25 M2– Sqrt[(dV1)^2+(dV2)^2]
optimal at [I1,I2]= [69,175]
CPV PSW Tuning LFI #25 M2– dV1
optimal at [I1,I2]= [69,175]
CPV PSW Tuning LFI #25 M2– dV2
optimal values at [I1,I2]= [69,185]
CPV PSW Tuning LFI #25 M2– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [24]

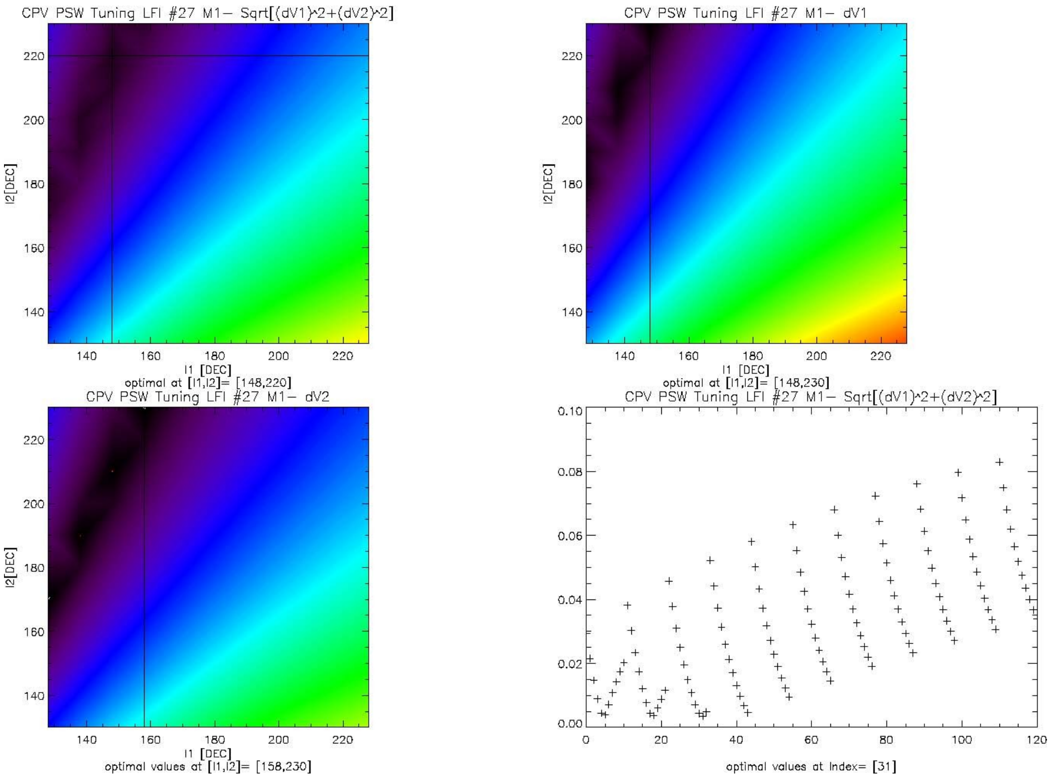

CPV PSW Tuning LFI #25 S1– Sqrt[(dV1)^2+(dV2)^2]
I1 [DEC]
I2[DEC]
optimal at [I1,I2]= [79,205]
CPV PSW Tuning LFI #25 S1– dV1
optimal at [I1,I2]= [79,225]
CPV PSW Tuning LFI #25 S1– dV2
optimal values at [I1,I2]= [79,175]
CPV PSW Tuning LFI #25 S1– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [38]
CPV PSW Tuning LFI #25 S2– Sqrt[(dV1)^2+(dV2)^2]
optimal at [I1,I2]= [119,225]
CPV PSW Tuning LFI #25 S2– dV1
optimal at [I1,I2]= [109,195]
CPV PSW Tuning LFI #25 S2– dV2
optimal values at [I1,I2]= [129,245]
CPV PSW Tuning LFI #25 S2– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [40]

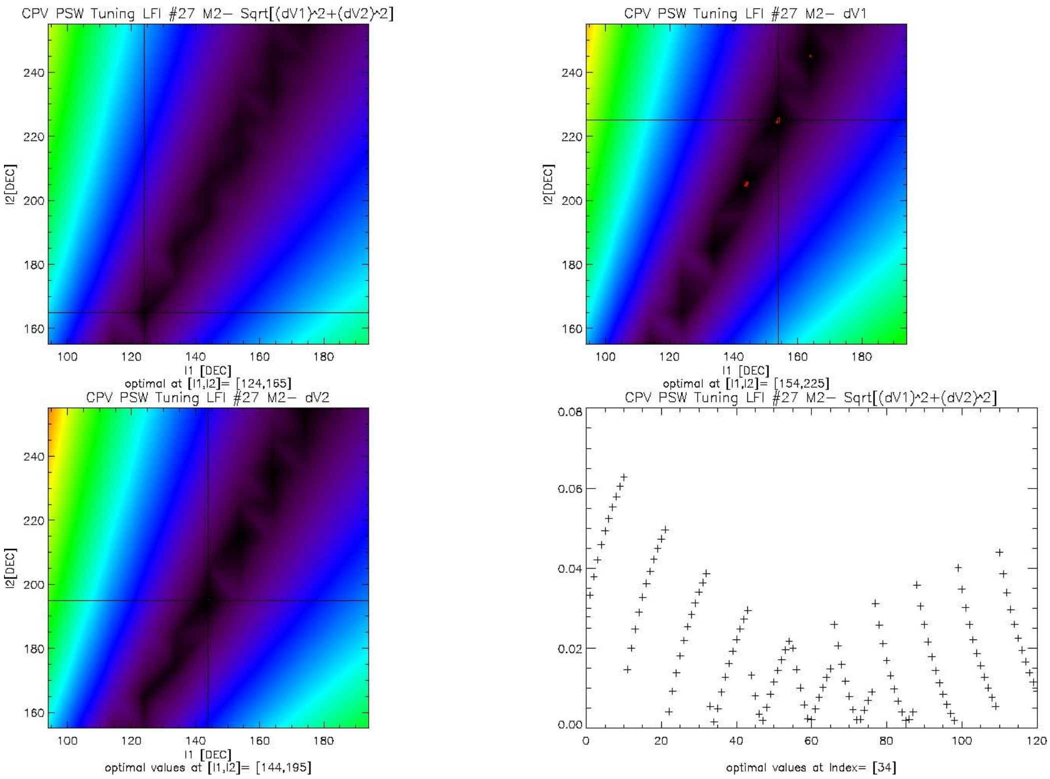

CPV PSW Tuning LFI #26 M1– Sqrt[(dV1)^2+(dV2)^2]
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [108,255]
CPV PSW Tuning LFI #26 M1– dV1
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [98,195]
CPV PSW Tuning LFI #26 M1– dV2
I2[DEC]
I1 [DEC]
optimal values at [I1,I2]= [98,225]
CPV PSW Tuning LFI #26 M1– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [76]

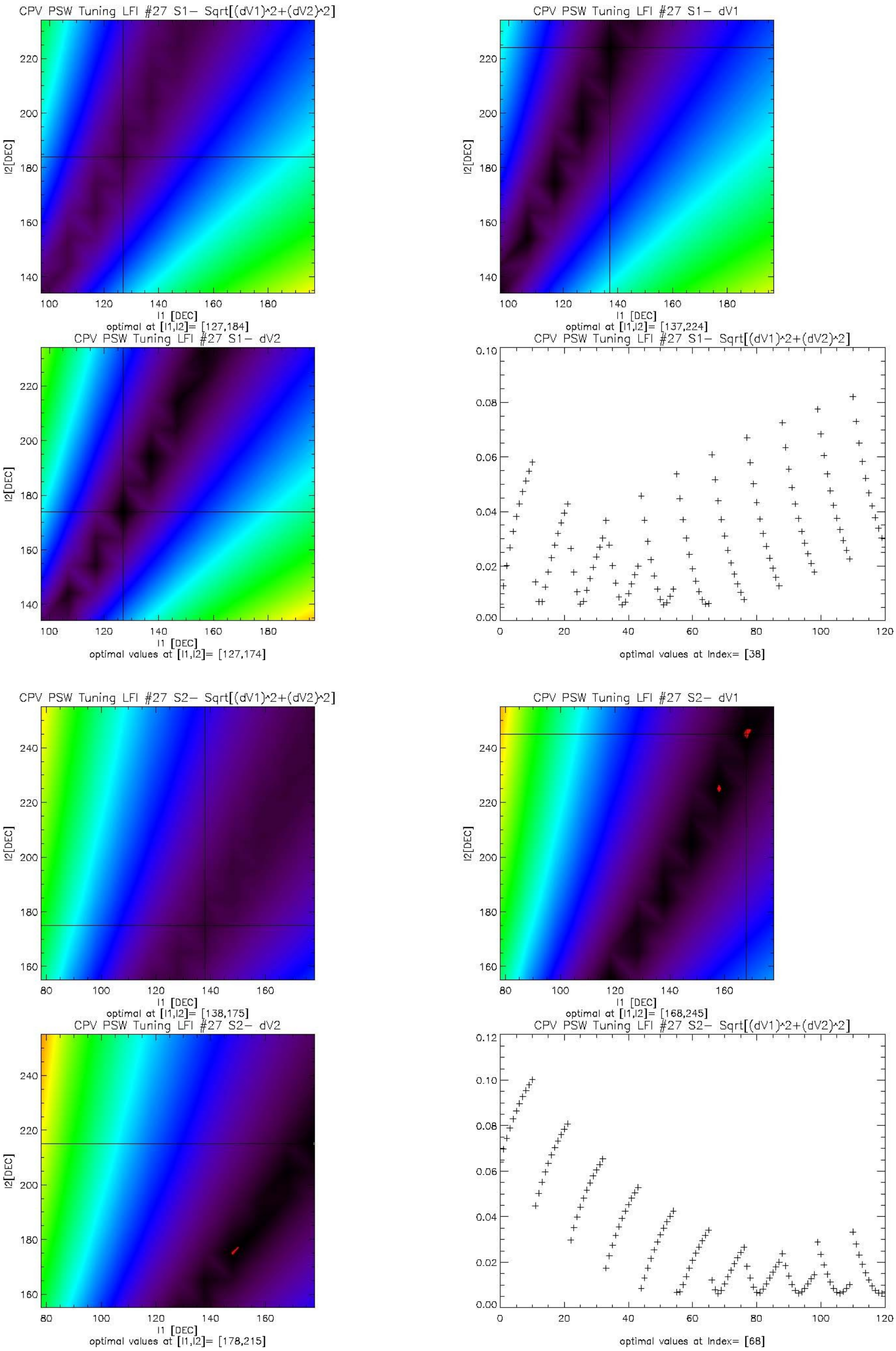

CPV PSW Tuning LFI #26 M2– Sqrt[(dV1)^2+(dV2)^2]
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [153,165]
CPV PSW Tuning LFI #26 M2– dV1
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [173,195]
CPV PSW Tuning LFI #26 M2– dV2
I2[DEC]
I1 [DEC]
optimal values at [I1,I2]= [153,155]
CPV PSW Tuning LFI #26 M2– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [67]

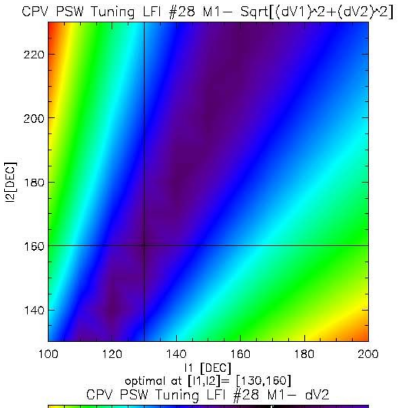

CPV PSW Tuning LFI #26 S1− Sqrt[(dV1)^2+(dV2)^2]
I1 [DEC]
I2[DEC]
optimal at [I1,I2]= [135,235]
CPV PSW Tuning LFI #26 S1− dV1
optimal at [I1,I2]= [145,235]
CPV PSW Tuning LFI #26 S1− dV2
optimal values at [I1,I2]= [135,255]
CPV PSW Tuning LFI #26 S1− Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [41]

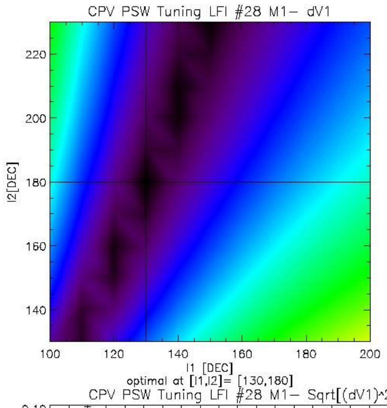

CPV PSW Tuning LFI #26 S2− Sqrt[(dV1)^2+(dV2)^2]
I1 [DEC]
I2[DEC]
optimal at [I1,I2]= [93,225]
CPV PSW Tuning LFI #26 S2− dV1
optimal at [I1,I2]= [103,245]
CPV PSW Tuning LFI #26 S2− dV2
optimal values at [I1,I2]= [83,195]
CPV PSW Tuning LFI #26 S2− Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [51]

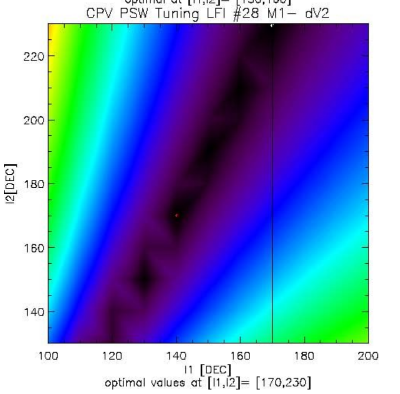

CPV PSW Tuning LFI #27 M1– Sqrt[(dV1)^2+(dV2)^2]
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [148,220]
CPV PSW Tuning LFI #27 M1– dV1
optimal at [I1,I2]= [148,230]
CPV PSW Tuning LFI #27 M1– dV2
optimal values at [I1,I2]= [158,230]
CPV PSW Tuning LFI #27 M1– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [31]

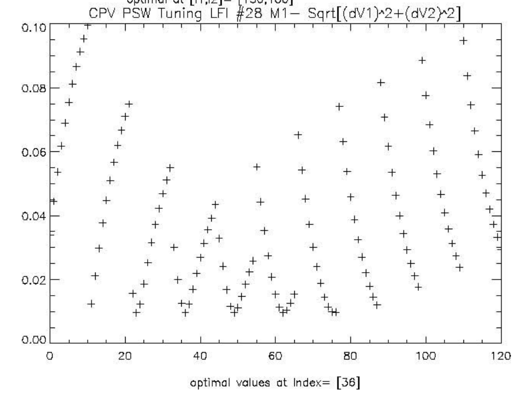

CPV PSW Tuning LFI #27 M2– Sqrt[(dV1)^2+(dV2)^2]
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [124,165]
CPV PSW Tuning LFI #27 M2– dV1
optimal at [I1,I2]= [154,225]
CPV PSW Tuning LFI #27 M2– dV2
optimal values at [I1,I2]= [144,195]
CPV PSW Tuning LFI #27 M2– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [34]

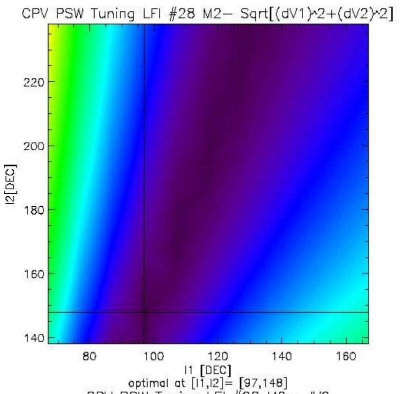

CPV PSW Tuning LFI #27 S1– Sqrt[(dV1)^2+(dV2)^2]
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [127,184]
CPV PSW Tuning LFI #27 S1– dV1
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [137,224]
CPV PSW Tuning LFI #27 S1– dV2
I2[DEC]
I1 [DEC]
optimal values at [I1,I2]= [127,174]
CPV PSW Tuning LFI #27 S1– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [38]
CPV PSW Tuning LFI #27 S2– Sqrt[(dV1)^2+(dV2)^2]
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [138,175]
CPV PSW Tuning LFI #27 S2– dV1
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [168,245]
CPV PSW Tuning LFI #27 S2– dV2
I2[DEC]
I1 [DEC]
optimal values at [I1,I2]= [178,215]
CPV PSW Tuning LFI #27 S2– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [68]

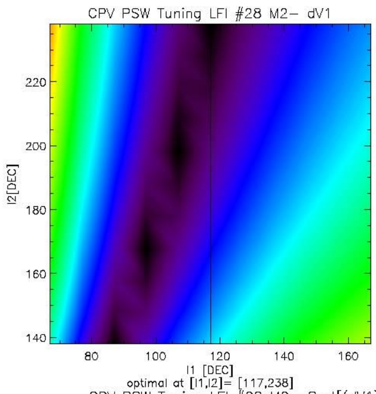

CPV PSW Tuning LFI #28 M1- Sqrt[(dV1)^2+(dV2)^2]
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [130,160]

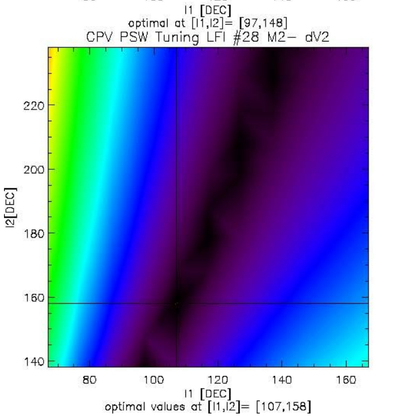

CPV PSW Tuning LFI #28 M1- dV1
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [130,180]

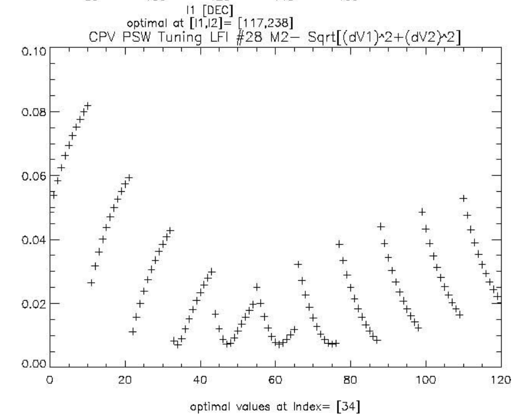

CPV PSW Tuning LFI #28 M1- dV2
I2[DEC]
I1 [DEC]
optimal values at [I1,I2]= [170,230]

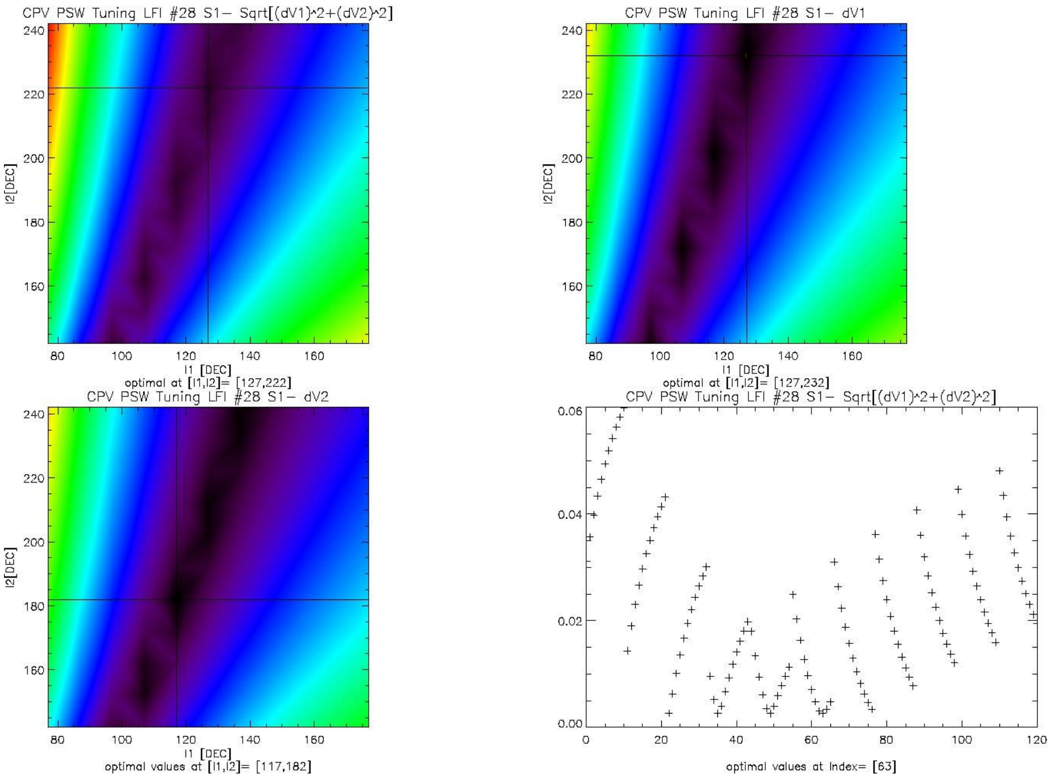

CPV PSW Tuning LFI #28 M1- Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [36]

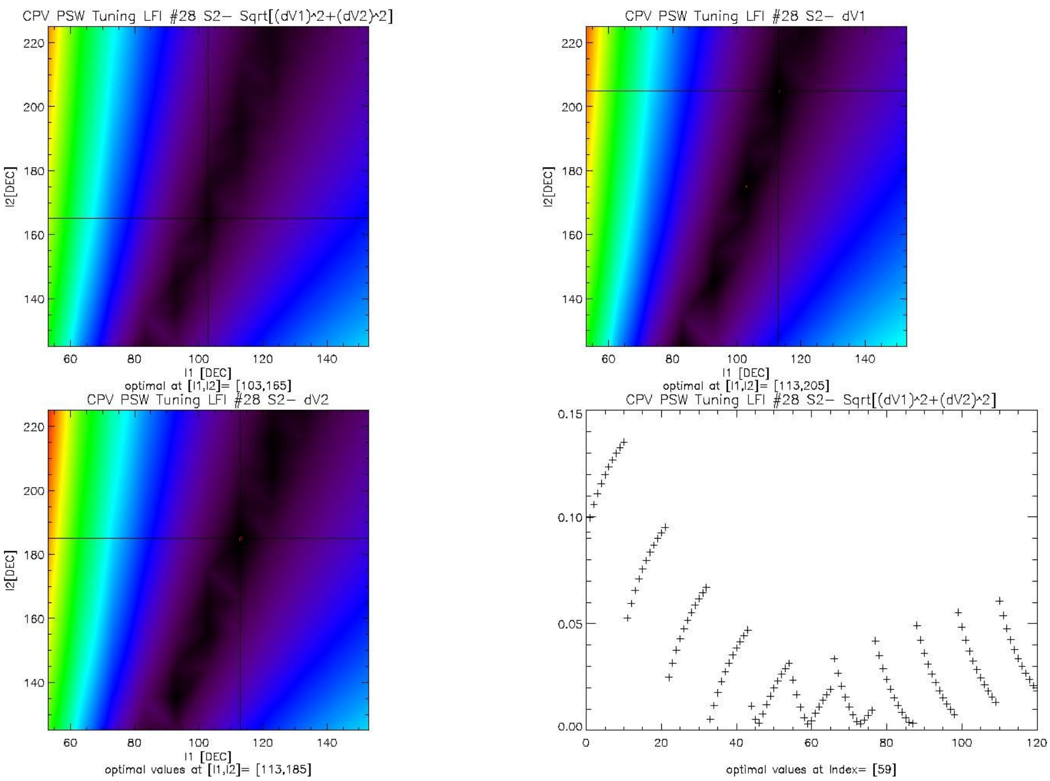

CPV PSW Tuning LFI #28 M2- Sqrt[(dV1)^2+(dV2)^2]
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [97,148]


CPV PSW Tuning LFI #28 M2- dV1
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [117,238]


CPV PSW Tuning LFI #28 M2- dV2
I2[DEC]
I1 [DEC]
optimal values at [I1,I2]= [107,158]


CPV PSW Tuning LFI #28 M2- Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [34]


CPV PSW Tuning LFI #28 S1– Sqrt[(dV1)^2+(dV2)^2]
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [127,222]
CPV PSW Tuning LFI #28 S1– dV1
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [127,232]
CPV PSW Tuning LFI #28 S1– dV2
I2[DEC]
I1 [DEC]
optimal values at [I1,I2]= [117,182]
CPV PSW Tuning LFI #28 S1– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [63]


CPV PSW Tuning LFI #28 S2– Sqrt[(dV1)^2+(dV2)^2]
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [103,165]
CPV PSW Tuning LFI #28 S2– dV1
I2[DEC]
I1 [DEC]
optimal at [I1,I2]= [113,205]
CPV PSW Tuning LFI #28 S2– dV2
I2[DEC]
I1 [DEC]
optimal values at [I1,I2]= [113,185]
CPV PSW Tuning LFI #28 S2– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [59]

## 1.7 Step 2

All the plots obtained in Step 1 have been evaluated one by one and compared qualitatively with the CSL report. A first assessment was reached considering that all the plots showed a good shape and a well defined nearly centred area of minimum.

In addition, here we report a quantitative comparison of the values of the bias currents $I_1$ and $I_2$ where de minimum of $\Delta V$ has been found during CSL and CPV tests. It should be noted that the significant differences are due to the fact that in some cases the best tuning condition was clearly in a region outside the grid scanned during CSL PSW tuning. It is the case of `LFI24M1`, `LFI25M2`, `LFI25S1`, `LFI26M1`, `LFI26S2`, `LFI27M1`, and marginally of `LFI24M2`, `LFI24S2`, `LFI27M2`, `LFI27S1`, `LFI27S2`, `LFI28S2` (See Figure 3, Figure 4, Figure 5, Figure 6, and Figure 7).

| | | CPV | | CSL | | Delta | | | | | CPV | | CSL | | Delta | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I1 | I2 | I1 | I2 | I1 | I2 | | | | I1 | I2 | I1 | I2 | I1 | I2 |
| LFI24 | M2 | 77 | 185 | 77 | 205 | 0 | -20 | | LFI27 | M1 | 148 | 220 | 178 | 180 | -30 | 40 |
| LFI24 | M1 | 98 | 215 | 128 | 250 | -30 | -35 | | LFI27 | M2 | 145 | 205 | 144 | 214 | 1 | -9 |
| LFI24 | S2 | 86 | 205 | 86 | 215 | 0 | -10 | | LFI27 | S1 | 127 | 184 | 117 | 154 | 10 | 30 |
| LFI24 | S1 | 84 | 235 | 84 | 235 | 0 | 0 | | LFI27 | S2 | 148 | 195 | 128 | 200 | 20 | -5 |
| | | | | | | | | | | | | | | | | |
| LFI25 | M1 | 154 | 245 | 174 | 235 | -20 | 10 | | LFI28 | M1 | 130 | 160 | 150 | 204 | -20 | -44 |
| LFI25 | M2 | 79 | 255 | 89 | 250 | -10 | 5 | | LFI28 | M2 | 127 | 228 | 105 | 164 | 22 | 64 |
| LFI25 | S1 | 79 | 205 | 89 | 250 | -10 | -45 | | LFI28 | S1 | 127 | 222 | 111 | 168 | 16 | 54 |
| LFI25 | S2 | 119 | 225 | 119 | 225 | 0 | 0 | | LFI28 | S2 | 103 | 165 | 93 | 155 | 10 | 10 |
| | | | | | | | | | | | | | | | | |
| LFI26 | M2 | 153 | 165 | 153 | 210 | 0 | -45 | | | | | | | | | |
| LFI26 | M1 | 108 | 255 | 98 | 245 | 10 | 10 | | | | | | | | | |
| LFI26 | S2 | 93 | 225 | 93 | 230 | 0 | -5 | | | | | | | | | |
| LFI26 | S1 | 135 | 235 | 135 | 230 | 0 | 5 | | | | | | | | | |

See the plots in the following section for a visual comparison.

## 1.8 Step 3

The optimal I1 and I2 pair derived automatically form the routine was checked one by one and eventually further optimized on the basis of the following criteria:

- Comparison with CSL

- Balancing of I1 and I2 with preference to high values of currents.

In this respect a correction was introduced in the following ACA:

```
LFI24M1, LFI25M2, LFI27M2, LFI27S2, LFI28M2
```

The plots in the following figures summarize the results and include also the comparison with the results obtained during the CSL campaign.

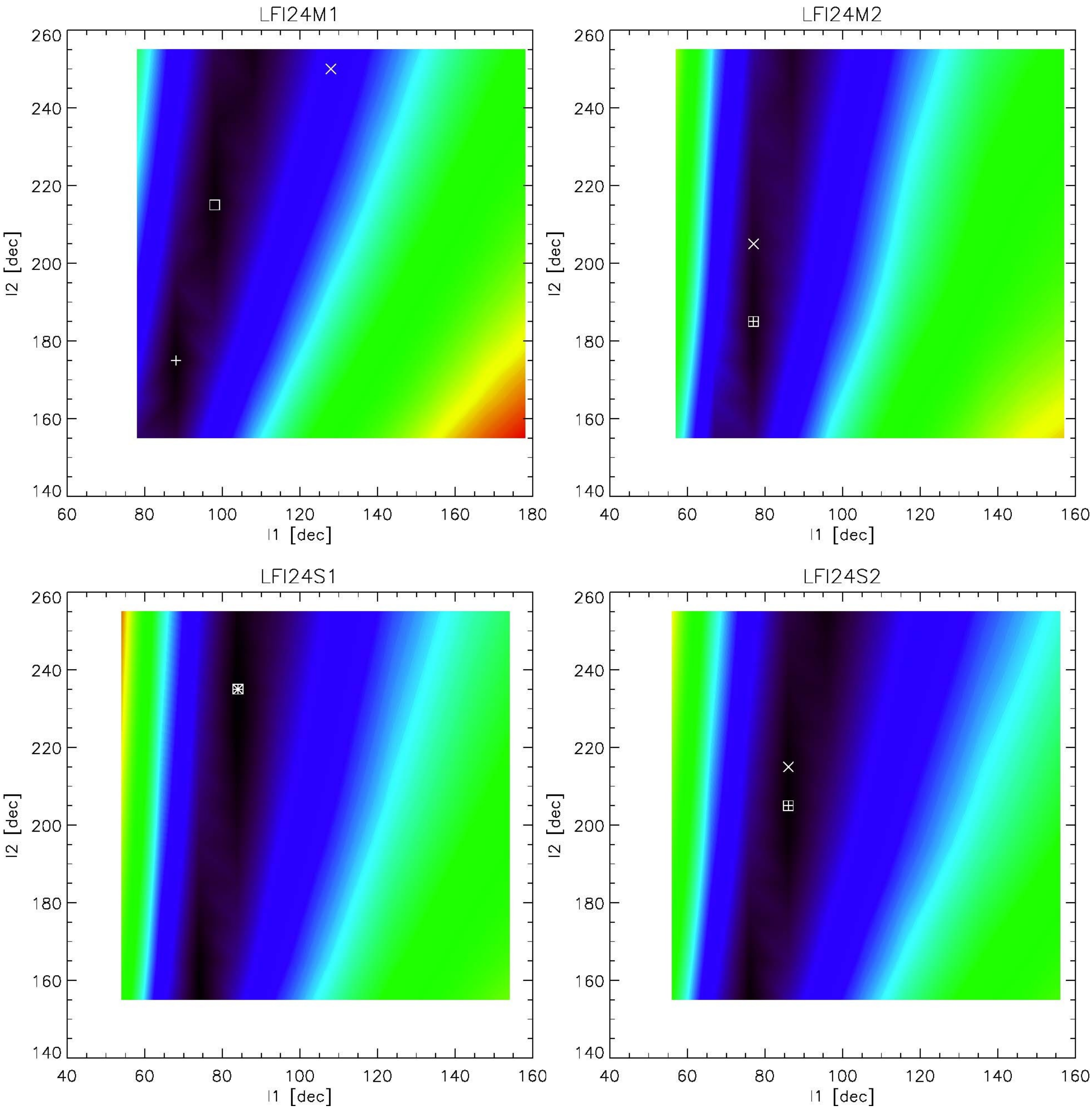



*Figure 11: RCA24 Phase switch results comparison. The coloured contour plot area is the data derived from CPV phase switch tuning test. Cross sign is the optimal point found during CSL test. Plus sign is the optimal point found during CPV test. The square point is the final optimal point chosen.*

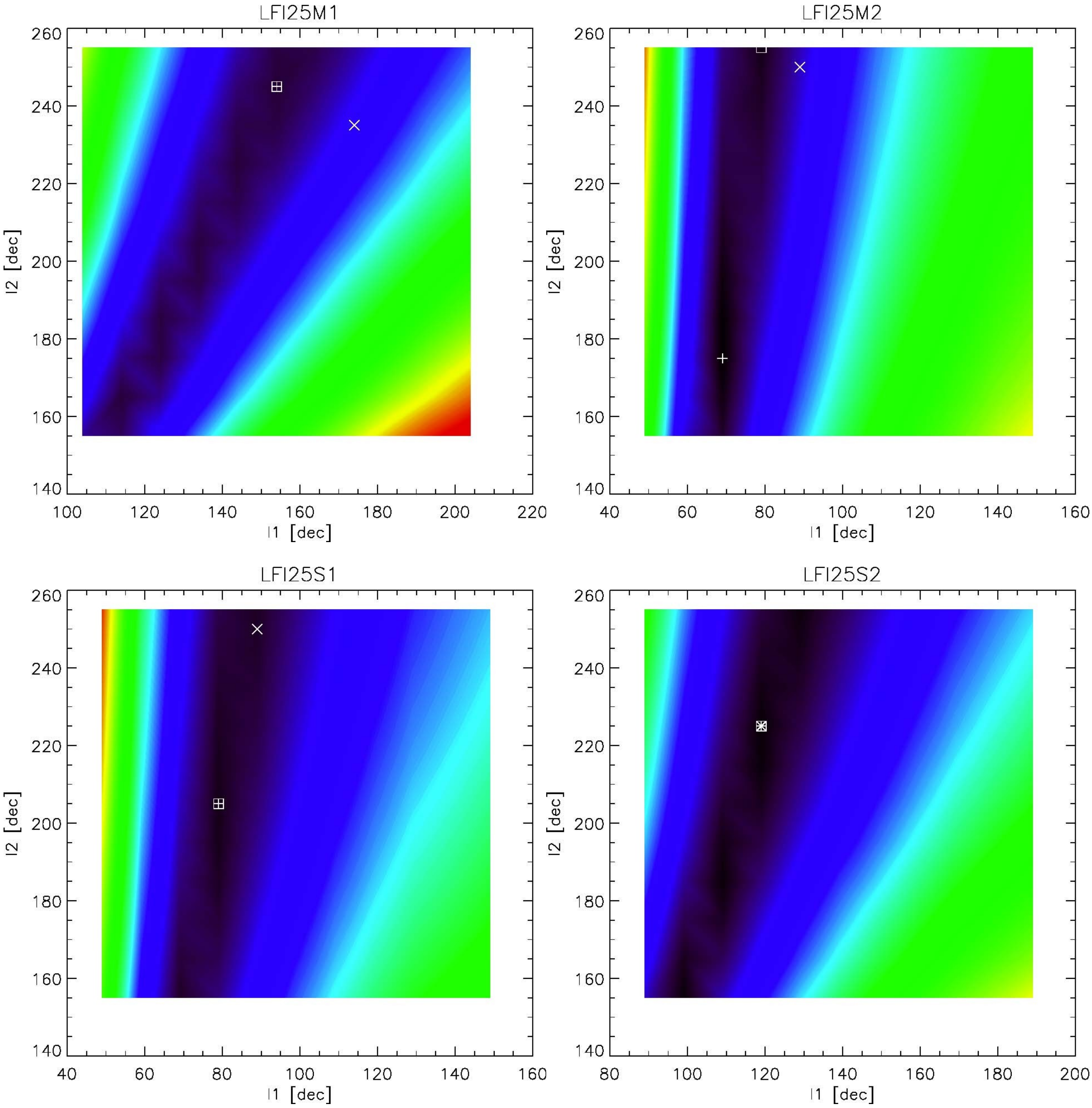



*Figure 12: RCA25 Phase switch results comparison. The coloured contour plot area is the data derived from CPV phase switch tuning test. Cross sign is the optimal point found during CSL test. Plus sign is the optimal point found during CPV test. The square point is the final optimal point chosen.*

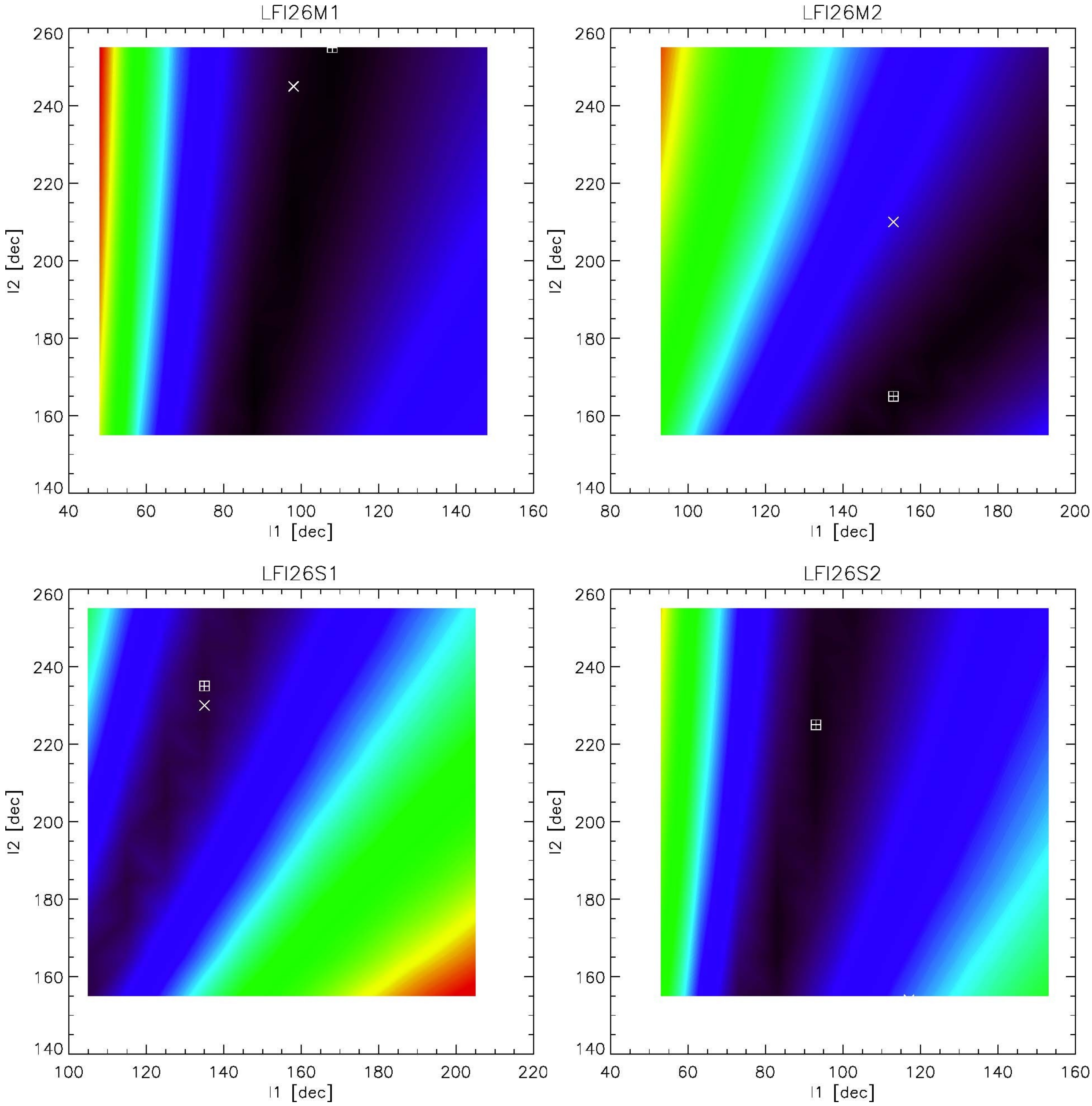



*Figure 13: RCA26 Phase switch results comparison. The coloured contour plot area is the data derived from CPV phase switch tuning test. Cross sign is the optimal point found during CSL test. Plus sign is the optimal point found during CPV test. The square point is the final optimal point chosen.*

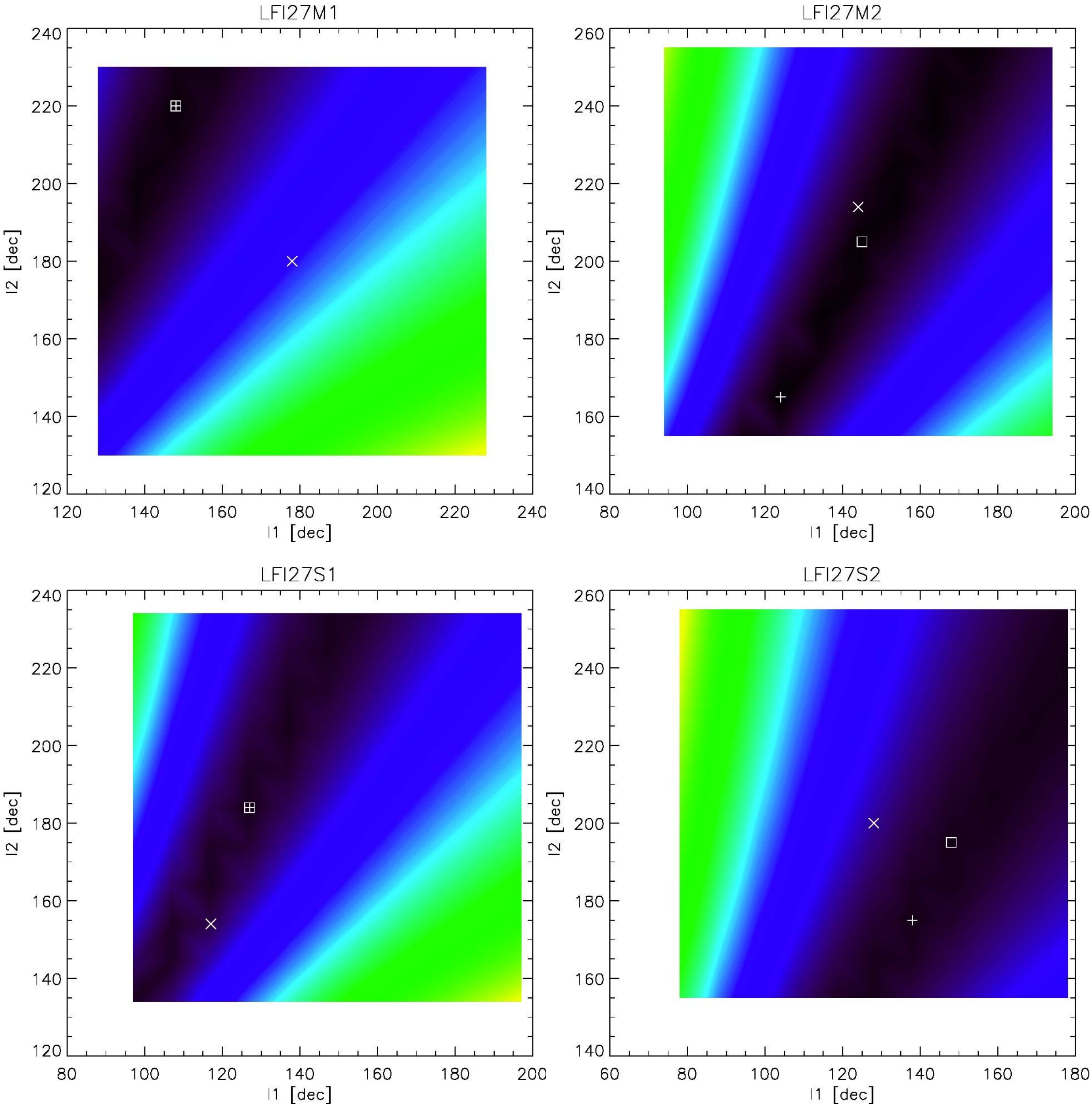



*Figure 14: RCA27 Phase switch results comparison. The coloured contour plot area is the data derived from CPV phase switch tuning test. Cross sign is the optimal point found during CSL test. Plus sign is the optimal point found during CPV test. The square point is the final optimal point chosen.*

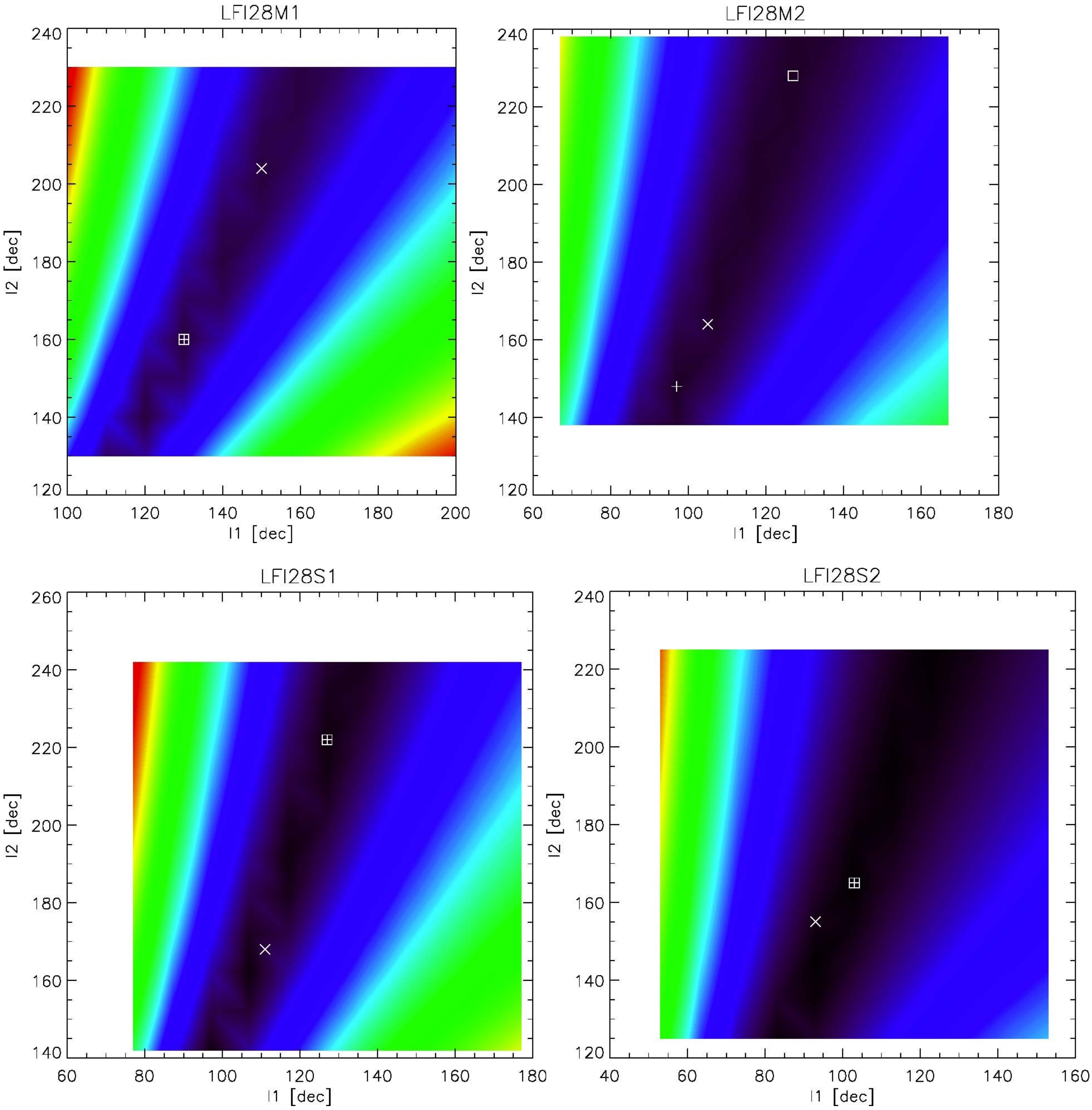



*Figure 15: RCA28 Phase switch results comparison. The coloured contour plot area is the data derived from CPV phase switch tuning test. Cross sign is the optimal point found during CSL test. Plus sign is the optimal point found during CPV test. The square point is the final optimal point chosen.*

## Results and Conclusions

The following table summarizes the final optimal phase switch currents. We remind that this tuning is performed only on the 30 and 44 GHz receivers. The 70 GHz receivers are biased at maximum current as lower currents would increase too much the phase switch rise time.

| | | | | | I1 | | I2 | | | | | | | I1 | | I2 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CH27** | **00** | **00** | **M1** | LP001320 | 148 | 94 | 220 | DC | **CH28** | **18** | **00** | **M1** | LP025320 | 130 | 82 | 160 | A0 |
| **CH27** | **01** | **01** | **M2** | LP002320 | 145 | 91 | 205 | CD | **CH28** | **19** | **01** | **M2** | LP026320 | 127 | 7F | 228 | E4 |
| **CH27** | **02** | **10** | **S1** | LP003320 | 127 | 7F | 184 | B8 | **CH28** | **1A** | **10** | **S1** | LP027320 | 127 | 7F | 222 | DE |
| **CH27** | **03** | **11** | **S2** | LP004320 | 148 | 94 | 195 | C3 | **CH28** | **1B** | **11** | **S2** | LP028320 | 103 | 67 | 165 | A5 |
| | | | | | | | | | | | | | | | | | |
| **CH24** | **04** | **00** | **M2** | LP005320 | 77 | 4D | 185 | B9 | **CH20** | **1C** | **00** | **S2** | LP029320 | 255 | FF | 255 | FF |
| **CH24** | **05** | **01** | **M1** | LP006320 | 98 | 62 | 215 | D7 | **CH20** | **1D** | **01** | **S1** | LP030320 | 255 | FF | 255 | FF |
| **CH24** | **06** | **10** | **S2** | LP007320 | 86 | 56 | 205 | CD | **CH20** | **1E** | **10** | **M1** | LP031320 | 255 | FF | 255 | FF |
| **CH24** | **07** | **11** | **S1** | LP008320 | 84 | 54 | 235 | EB | **CH20** | **1F** | **11** | **M2** | LP032320 | 255 | FF | 255 | FF |
| | | | | | | | | | | | | | | | | | |
| **CH21** | **08** | **00** | **S2** | LP009320 | 255 | FF | 255 | FF | **CH19** | **20** | **00** | **S2** | LP033320 | 255 | FF | 255 | FF |
| **CH21** | **09** | **01** | **S1** | LP010320 | 255 | FF | 255 | FF | **CH19** | **21** | **01** | **S1** | LP034320 | 255 | FF | 255 | FF |
| **CH21** | **0A** | **10** | **M1** | LP011320 | 255 | FF | 255 | FF | **CH19** | **22** | **10** | **M1** | LP035320 | 255 | FF | 255 | FF |
| **CH21** | **0B** | **11** | **M2** | LP012320 | 255 | FF | 255 | FF | **CH19** | **23** | **11** | **M2** | LP036320 | 255 | FF | 255 | FF |
| | | | | | | | | | | | | | | | | | |
| **CH22** | **0C** | **00** | **S2** | LP013320 | 255 | FF | 255 | FF | **CH18** | **24** | **00** | **S2** | LP037320 | 255 | FF | 255 | FF |
| **CH22** | **0D** | **01** | **S1** | LP014320 | 255 | FF | 255 | FF | **CH18** | **25** | **01** | **S1** | LP038320 | 255 | FF | 255 | FF |
| **CH22** | **0E** | **10** | **M1** | LP015320 | 255 | FF | 255 | FF | **CH18** | **26** | **10** | **M1** | LP039320 | 255 | FF | 255 | FF |
| **CH22** | **0F** | **11** | **M2** | LP016320 | 255 | FF | 255 | FF | **CH18** | **27** | **11** | **M2** | LP040320 | 255 | FF | 255 | FF |
| | | | | | | | | | | | | | | | | | |
| **CH23** | **10** | **00** | **S2** | LP017320 | 255 | FF | 255 | FF | **CH26** | **28** | **00** | **M2** | LP041320 | 153 | 99 | 165 | A5 |
| **CH23** | **11** | **01** | **S1** | LP018320 | 255 | FF | 255 | FF | **CH26** | **29** | **01** | **M1** | LP042320 | 108 | 6C | 255 | FF |
| **CH23** | **12** | **10** | **M1** | LP019320 | 255 | FF | 255 | FF | **CH26** | **2A** | **10** | **S2** | LP043320 | 93 | 5D | 225 | E1 |
| **CH23** | **13** | **11** | **M2** | LP020320 | 255 | FF | 255 | FF | **CH26** | **2B** | **11** | **S1** | LP044320 | 135 | 87 | 235 | EB |
| | | | | | | | | | | | | | | | | | |
| **CH25** | **14** | **00** | **M1** | LP021320 | 154 | 9A | 245 | F5 | | | | | | | | | |
| **CH25** | **15** | **01** | **M2** | LP022320 | 79 | 4F | 255 | FF | | | | | | | | | |
| **CH25** | **16** | **10** | **S1** | LP023320 | 79 | 4F | 205 | CD | | | | | | | | | |
| **CH25** | **17** | **11** | **S2** | LP024320 | 119 | 77 | 225 | E1 | | | | | | | | | |

Also the 4KHz status was provided as an output of the analysis. Since no problems were observed in the output voltage for each PS tuning, the baseline values were used and reported in the following table.

| | | 4KHZ A/C | | 4KHZ B/D | | PS A/C | | PS B/D | |
|---|---|---|---|---|---|---|---|---|---|
| **CH27** | LP049320 | C24 | 0 | C25 | 1 | C26 | 0 | C27 | 0 |
| **CH24** | LP050320 | C24 | 0 | C25 | 1 | C26 | 0 | C27 | 0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **CH21** | LP051320 | C24 | 0 | C25 | 1 | C26 | 1 | C27 | 0 |
| **CH22** | LP052320 | C24 | 0 | C25 | 1 | C26 | 1 | C27 | 0 |
| **CH23** | LP053320 | C24 | 1 | C25 | 0 | C26 | 1 | C27 | 0 |
| **CH25** | LP054320 | C24 | 0 | C25 | 1 | C26 | 0 | C27 | 0 |
| **CH28** | LP055320 | C24 | 0 | C25 | 1 | C26 | 1 | C27 | 0 |
| **CH20** | LP056320 | C24 | 0 | C25 | 1 | C26 | 1 | C27 | 0 |
| **CH19** | LP057320 | C24 | 0 | C25 | 1 | C26 | 1 | C27 | 0 |
| **CH18** | LP058320 | C24 | 0 | C25 | 1 | C26 | 1 | C27 | 0 |
| **CH26** | LP059320 | C24 | 0 | C25 | 1 | C26 | 0 | C27 | 0 |

The comparison with CSL showed a good matching and the robustness of the tuning strategy.

# Appendix A Test procedure and Check list.

| Step | Description | START REF. | DURATION | Time | RCA | YES | NO | Notes |
|---|---|---|---|---|---|---|---|---|
| 9 | P/S Tuning (UM section 13.1.2.6) | 0.00.00 | 0.00.00 | | | | | |
| | RCA 24 and 25 | 0.00.00 | 0.00.00 | | 24,25 | | | |
| | Disable A/C 4kHz (but RCA 23) | 0.00.00 | 0.00.02 | | All ~~(23)~~ | | | Already set to 0 |
| | Disable B/D 4kHz | 0.00.02 | 0.00.02 | 1623965403.28 | All | | | Not applied to RCA23 |
| | Set A/C P/S Status (0) (but RCA 23) | 0.00.04 | 0.00.02 | 1623965405.28 | All ~~(23)~~ | | | |
| | Set B/D P/S Status (0) (but RCA 23) | 0.00.06 | 0.00.02 | | All ~~(23)~~ | | | already set |
| | Set A/C P/S Status (1) (but RCA 23) | 0.00.08 | 0.00.02 | 1623965409.28 | All ~~(23)~~ | | | |
| | Enable B/D 4kHz (but RCA 23) | 0.00.10 | 0.00.02 | 1623965411.28 | All ~~(23)~~ | | | |
| 9.1 | Set zero bias on ACA1 | 0.00.12 | 0.00.06 | 1623965417.28 | 24,25-1 | | | |
| 9.2 | Perform Iswitch1 vs Iswitch2 tuning for ACA2 | 0.00.18 | 0.44.42 | | 24,25-2 | | | |
| 9.3 | Set zero bias on ACA2 | 0.45.00 | 0.00.06 | 1623968407.28 | 24,25-2 | | | |
| 9.4 | Set Cryo bias on ACA1 | 0.45.06 | 0.00.06 | 1623968413.28 | 24,25-1 | | | |
| 9.5 | Disable B/D 4kHz (but RCA 23) | 0.45.12 | 0.00.02 | 1623968415.28 | All ~~(23)~~ | | | |
| | Set B/D P/S Status (0) (but RCA 23) | 0.45.14 | 0.00.02 | | All ~~(23)~~ | | | Already set |
| 9.6 | Enable A/C 4kHz (but RCA 23) | 0.45.16 | 0.00.02 | 1623968419.28 | All ~~(23)~~ | | | |
| 9.7 | Perform Iswitch1 vs Iswitch2 tuning for ACA1 | 0.45.18 | 0.44.42 | | 24,25-1 | | | |
| 9.8 | Set Cryo bias on ACA1 and ACA2 | 1.30.00 | 0.00.06 | 1623971399.28 | 24,25-1,2 | | | ACA1 already set |
| 9.9 | Disable A/C 4kHz (but RCA 23) | 1.30.06 | 0.00.02 | 1623971401.31 | All ~~(23)~~ | | | |
| | Set A/C P/S Status (0) (but RCA 23) | 1.30.08 | 0.00.02 | 1623971403.28 | All ~~(23)~~ | | | |
| 9.1 | Enable B/D 4kHz (but RCA 23) | 1.30.10 | 0.00.02 | 1623971405.28 | All ~~(23)~~ | | | |
| 9.11 | Set zero bias on ACA3 | 1.30.12 | 0.00.06 | 1623971411.28 | 24,25-3 | | | |
| 9.12 | Perform Iswitch1 vs Iswitch2 tuning for ACA4 | 1.30.18 | 0.44.42 | | 24,25-4 | | | |
| 9.13 | Set zero bias on ACA4 | 2.15.00 | 0.00.06 | 1623974391.28 | 24,25-4 | | | |
| 9.14 | Set Cryo bias on ACA3 | 2.15.06 | 0.00.06 | 1623974397.28 | 24,25-3 | | | |
| 9.15 | Disable B/D 4kHz (but RCA 23) | 2.15.12 | 0.00.02 | 1623974399.28 | All ~~(23)~~ | | | |
| | Set B/D P/S Status (0) (but RCA 23) | 2.15.14 | 0.00.02 | | All ~~(23)~~ | | | Already set |
| 9.16 | Enable A/C 4kHz (but RCA 23) | 2.15.16 | 0.00.02 | 1623974403.28 | All ~~(23)~~ | | | |
| 9.17 | Perform Iswitch1 vs Iswitch2 tuning for ACA3 | 2.15.18 | 0.44.42 | | 24,25-3 | | | |
| 9.18 | Set Cryo bias on ACA3 | 3.00.00 | 0.00.06 | | 24,25-3 | | | already set |
| 9.19 | Set Cryo bias on ACA4 of RCA 25 | 3.00.06 | 0.00.06 | 1623977389.28 | 24,25-4 | | | |
| 9.2 | Set Vg2 on ACA4 of RCA 24 | 3.00.12 | 0.00.02 | 1623977391.28 | 24,25-4 | | | |
| 9.21 | Set Vdrain on ACA4 of RCA 24 | 3.00.14 | 0.00.02 | 1623977393.28 | 24,25-4 | | | |
| 9.22 | Set Vg1 on ACA4 of RCA 24 | 3.00.16 | 0.00.02 | 1623977395.28 | 24,25- | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | 4 | | | |
| 9.23 | Set Iswitch1 on ACA4 of RCA 24 | 3.00.18 | 0.00.02 | 1623977397.28 | 24,25-4 | | | |
| 9.24 | Set Iswitch2 on ACA4 of RCA 24 | 3.00.20 | 0.00.02 | 1623977399.28 | 24,25-4 | | | |
| 9.25 | Disable A/C 4kHz (but RCA 23) | 3.00.22 | 0.00.02 | 1623977401.28 | All (23) | | | |
| | Set A/C P/S Status (0) (but RCA 23) | 3.00.24 | 0.00.02 | | All (23) | | | |
| 9.26 | Enable B/D 4kHz (but RCA 23) | 3.00.26 | 0.00.02 | 1623977405.28 | All (23) | | | |
| | RCA 26 and 27 | 3.00.28 | 0.00.00 | | 26,27 | | | |
| 9.27 | Set zero bias on ACA1 | 3.00.28 | 0.00.06 | 1623977411.28 | 26,27-1 | | | Already set |
| 9.28 | Perform Iswitch1 vs Iswitch2 tuning for ACA2 | 3.00.34 | 0.45.26 | | 26,27-2 | | | |
| 9.29 | Set zero bias on ACA2 | 3.46.00 | 0.00.06 | 1623980391.28 | 26,27-2 | | | |
| 9.3 | Set Cryo bias on ACA1 | 3.46.06 | 0.00.06 | 1623980397.28 | 26,27-1 | | | |
| 9.31 | Disable B/D 4kHz (but RCA 23) | 3.46.12 | 0.00.02 | 1623980399.28 | All (23) | | | |
| | Set B/D P/S Status (0) (but RCA 23) | 3.46.14 | 0.00.02 | | All (23) | | | |
| 9.32 | Enable A/C 4kHz (but RCA 23) | 3.46.16 | 0.00.02 | 1623980403.28 | All (23) | | | |
| 9.33 | Perform Iswitch1 vs Iswitch2 tuning for ACA1 | 3.46.18 | 0.44.42 | | 26,27-1 | | | |
| 9.34 | Set Cryo bias on ACA1 and ACA2 | 4.31.00 | 0.00.06 | 1623983383.28 | 26,27-1,2 | | | ACA1 already set |
| 9.35 | Disable A/C 4kHz (but RCA 23) | 4.31.06 | 0.00.02 | 1623983385.28 | All (23) | | | |
| | Set A/C P/S Status (0) (but RCA 23) | 4.31.08 | 0.00.02 | | All (23) | | | |
| 9.36 | Enable B/D 4kHz (but RCA 23) | 4.31.10 | 0.00.02 | 1623983389.28 | All (23) | | | |
| 9.37 | Set zero bias on ACA3 | 4.31.12 | 0.00.06 | 1623983395.42 | 26,27-3 | | | |
| 9.38 | Perform Iswitch1 vs Iswitch2 tuning for ACA4 | 4.31.18 | 0.44.42 | | 26,27-4 | | | |
| 9.39 | Set zero bias on ACA4 | 5.16.00 | 0.00.06 | 1623986375.28 | 26,27-4 | | | |
| 9.4 | Set Cryo bias on ACA3 | 5.16.06 | 0.00.06 | 1623986381.28 | 26,27-3 | | | |
| 9.41 | Disable B/D 4kHz (but RCA 23) | 5.16.12 | 0.00.02 | 1623986383.28 | All (23) | | | |
| | Set B/D P/S Status (0) (but RCA 23) | 5.16.14 | 0.00.02 | | All (23) | | | |
| 9.42 | Enable A/C 4kHz (but RCA 23) | 5.16.16 | 0.00.02 | 1623986387.28 | All (23) | | | |
| 9.43 | Perform Iswitch1 vs Iswitch2 tuning for ACA3 | 5.16.18 | 0.44.42 | | 26,27-3 | | | |
| 9.44 | Set Cryo bias on ACA3 and ACA4 | 6.01.00 | 0.00.06 | 1623989367.28 | 26,27-3,4 | | | ACA3 already set |
| 9.45 | Disable A/C 4kHz (but RCA 23) | 6.01.06 | 0.00.02 | 1623989369.28 | All (23) | | | |
| | Set A/C P/S Status (0) (but RCA 23) | 6.01.08 | 0.00.02 | | All (23) | | | Already set |
| 9.46 | Enable B/D 4kHz (but RCA 23) | 6.01.10 | 0.00.02 | 1623989373.28 | All (23) | | | |
| | RCA 28 | 6.01.12 | 0.00.00 | | 28-1 | | | |
| 9.47 | Set zero bias on ACA1 | 6.01.12 | 0.00.06 | 1623989379.28 | 28-2 | | | |
| 9.48 | Perform Iswitch1 vs Iswitch2 tuning for ACA2 | 6.01.18 | 0.44.42 | | 28-2 | | | |
| 9.49 | Set zero bias on ACA2 | 6.46.00 | 0.00.06 | 1623992359.28 | 28-2 | | | |
| 9.5 | Power on ACA1 and ACA2 with Soft S. On proc | 6.46.06 | 0.00.06 | 1623992365.28 | 28-1,2 | | | |
| 9.5 | Power on ACA1 and ACA2 with | 6.46.12 | 0.00.06 | 1623992371.28 | 28-1,2 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Soft S. On proc | | | | | | | |
| 9.5 | Power on ACA1 and ACA2 with Soft S. On proc | 6.46.18 | 0.00.06 | 1623992377.28 | 28-1,2 | | | |
| 9.5 | Power on ACA1 and ACA2 with Soft S. On proc | 6.46.24 | 0.00.06 | 1623992383.28 | 28-1,2 | | | |
| 9.51 | Set zero bias on ACA2 | 6.46.30 | 0.00.06 | 1623992389.28 | 28-2 | | | |
| 9.52 | Disable B/D 4kHz (but RCA 23) | 6.46.36 | 0.00.02 | 1623992391.28 | All ~~(23)~~ | | | |
| | Set B/D P/S Status (0) (but RCA 23) | 6.46.38 | 0.00.02 | | All ~~(23)~~ | | | Already set |
| 9.53 | Enable A/C 4kHz (but RCA 23) | 6.46.40 | 0.00.02 | 1623992395.28 | All ~~(23)~~ | | | |
| 9.54 | Perform Iswitch1 vs Iswitch2 tuning for ACA1 | 6.46.42 | 0.45.18 | | 28-1 | | | |
| 9.55 | Set zero bias on ACA1 | 7.32.00 | 0.00.06 | 1623995375.28 | 28-1 | | | |
| 9.56 | Power on ACA1 and ACA2 with Soft S. On proc | 7.32.06 | 0.00.06 | 1623995381.28 | 28-1,2 | | | |
| 9.56 | Power on ACA1 and ACA2 with Soft S. On proc | 7.32.12 | 0.00.06 | 1623995387.28 | 28-1,2 | | | |
| 9.56 | Power on ACA1 and ACA2 with Soft S. On proc | 7.32.18 | 0.00.06 | 1623995393.28 | 28-1,2 | | | |
| 9.56 | Power on ACA1 and ACA2 with Soft S. On proc | 7.32.24 | 0.00.06 | 1623995399.28 | 28-1,2 | | | |
| 9.57 | Disable A/C 4kHz (but RCA 23) | 7.32.30 | 0.00.02 | 1623995401.28 | All ~~(23)~~ | | | |
| | Set A/C P/S Status (0) (but RCA 23) | 7.32.32 | 0.00.02 | | All ~~(23)~~ | | | Already set |
| 9.58 | Enable B/D 4kHz (but RCA 23) | 7.32.34 | 0.00.02 | 1623995405.28 | All ~~(23)~~ | | | |
| 9.59 | Set zero bias on ACA3 | 7.32.36 | 0.00.06 | 1623995411.28 | 28-3 | | | |
| 9.6 | Perform Iswitch1 vs Iswitch2 tuning for ACA4 | 7.32.42 | 0.45.18 | | 28-4 | | | |
| 9.61 | Set zero bias on ACA4 | 8.18.00 | 0.00.06 | 1623998391.29 | 28-4 | | | |
| 9.62 | Set Cryo bias on ACA3 | 8.18.06 | 0.00.06 | 1623998397.29 | 28-3 | | | |
| 9.63 | Disable B/D 4kHz (but RCA 23) | 8.18.12 | 0.00.02 | 1623998399.29 | All ~~(23)~~ | | | |
| | Set B/D P/S Status (0) (but RCA 23) | 8.18.14 | 0.00.02 | | All ~~(23)~~ | | | Already set |
| 9.64 | Enable A/C 4kHz (but RCA 23) | 8.18.16 | 0.00.02 | 1623998403.29 | All ~~(23)~~ | | | |
| 9.65 | Perform Iswitch1 vs Iswitch2 tuning for ACA3 | 8.18.18 | 0.44.42 | | 28-3 | | | |
| 9.66 | Set Cryo bias on ACA3 and ACA4 | 9.03.00 | 0.00.06 | 1624001383.29 | 28-3,4 | | | ACA3 already set |
| 9.67 | Disable A/C 4kHz | 9.03.06 | 0.00.02 | 1624001385.29 | All | | | |
| 9.68 | Disable B/D 4kHz | 9.03.08 | 0.00.02 | | All | | | Not present since already dis-abled |
| 9.69 | Set A/C P/S Status (0) | 9.03.10 | 0.00.02 | 1624001389.29 | All | | | Only for 23 |
| 9.7 | Set B/D P/S Status (0) | 9.03.12 | 0.00.02 | | All | | | already set |
| 9.71 | Apply Default DAE Configura-tion as current configura-tion | 9.03.14 | 0.00.02 | 1624001393.29 | All | | | Non torna la posizione dei PS che e' settata A/C = 1 su tutte le catene |
| | | 9.03.16 | 0.00.00 | | | | | |
| 9bis | Set NEW values and store as Default Configuration | 0.00.00 | 0.00.00 | | All | | | |
| 9bis.1 | Set Iswitch1 new values | 0.00.00 | 0.00.02 | | All | | | |
| | Set Iswitch2 new values | 0.00.02 | 0.00.02 | | All | | | |
| | Disable A/C 4kHz | 0.00.04 | 0.00.02 | | All | | | |
| | Disable B/D 4kHz | 0.00.06 | 0.00.02 | | All | | | |
| | Set PS status = 0 (A/C) | 0.00.08 | 0.00.02 | | All | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Set PS status = 0 (B/D) | 0.00.10 | 0.00.02 | | All | | | |
| 9bis.2 | Set PS status = 1 (A/C) on selected RCAs | 0.00.12 | 0.00.02 | | | | | |
| 9bis.3 | Set PS status = 1 (B/D) on selected RCAs | 0.00.14 | 0.00.02 | | | | | |
| 9bis.4 | Enable 4kHz (A/C) RCA23 & on selected RCAs | 0.00.16 | 0.00.02 | | | | | |
| 9bis.5 | Enable 4kHz (B/D) on selec-ted RCAs (but RCA 23) | 0.00.18 | 0.00.02 | | All ~~(23)~~ | | | |
| 9bis.7 | Set DAE Gain values | 0.00.20 | 0.00.02 | | All | | | |
| 9bis.8 | Set DAE offset values | 0.00.22 | 0.00.02 | | All | | | |
| | Acquire Data | 0.00.24 | 0.10.00 | | | | | |
| | Set Iswitch1 new values | 0.00.00 | 0.00.02 | | All | | | |
| | Set Iswitch2 new values | 0.00.02 | 0.00.02 | | All | | | |
| | Acquire Data2 | 0.00.04 | 1.10.00 | | | | | |
| | Set Iswitch1 new values | 1.10.04 | 0.00.02 | | All | | | |
| | Set Iswitch2 new values | 1.10.06 | 0.00.02 | | All | | | |
| 9bis.6 | Save as default configura-tion | 1.10.08 | 0.00.02 | | | | | |
| | end of the test | 1.10.10 | 0.00.00 | | | | | |

# Appendix B Script

```
pro cpv_psw_script


; SCRIPT TO ANALYSE PHASE SWITCH TUNING DURING CPV

; DATE: 14 June 2009
; Version : 1.0
; Author: Fabrizio Villa
;         INAF / IASF - Bologna
;         villa@iasfbo.inaf.it
;
; DESCRIPTION
; this script analyse phase switch tuning test, find the  optimal bias condition and compare
; results with the CSL data.

; Requirements:


;     test_raa_dir = 'D:\RAA\' ; CHANGE WITH THE APPROPRIATE DIRECTORY


; forward_function lama_tune_phase_switch_currents_csl
; forward_function lama_select_test
; forward_function read_rca_psw_tun

 ; GRID LIMIT SPECIFICATIONS --> See PROCEDURE DOCUMENT
 ; Data = [I1start, I1stop, I2start, I2stop, NpointsI1, NpointsI2]
 ; This will be used to check the currents from hk data.



;   grid_limits = intarr(6,4,5)

;   datadir = get_lifedir() + path_sep() + 'lama'+path_sep()+'lama_tun'+path_sep()
;  check = file_test(datadir, /directory)
;  If ~check Then Begin
;      msg = 'Data directory ' + datadir + ' does not exist or is not a directory. Returning'
;      write_log_message, function_name, msg
;      return
;  EndIf

; openr,Unit, datadir+'PSW_tuning_grid_limits_cls.dat' ,/get_lun
; readf,Unit,grid_limits
; close,Unit

forward_function pegaso_tune_phase_switch_currents


; General decalations
 time_start = 1623963422.d0
 time_end =1624002326.0d0

; time_start= 1623971414.3d0 ; per RCA25S2
; time_end = 1623974320.0d0  ; per RCA25S2

; time_start= 1623971414.3d0 ; per RCA24S1
; time_end = 1623974329.0d0  ; per RCA24S1

; time_start= 1623977414.3d0 ; per RCA26M1
; time_end =  1623980338.9d0 ; per RCA26M1

; time_start= 1623992402.0d0 ; per RCA28M1
; time_end =  1623995320.0d0 ; per RCA28M1


; time_start=1623989383.0d0  ; per RCA28M2
; time_end =  1623992303.0d0 ; per RCA28M2

time_window = [time_start, time_end]
caller='pegaso'
proc_type='AVR1'
time_offset=1.d0
time_crop=0.d0 ; DO NOT CHANGE!!!
time_delay=0.d0 ; DO NOT CHANGE !!!


;; DEFINITION OF GRID POINTS
```

```
i1 = dblarr(5,4,2) ; 5 RCAs, 4 PSWs, -- 0 = start; 1 = stop
i2 = dblarr(5,4,2)

;----------------------
;CH24  0 57  155 157 255
;CH24  1 78  155 178 255
;CH24  2 56  155 156 255
;CH24  3 54  155 154 255

i1[0,*,0]=[57,78,56,54]
i1[0,*,1]=[157,178,156,154]
i2[0,*,0]=[155,155,155,155]
i2[0,*,1]=[255,255,255,255]

;CH25  0 104 155 204 255
;CH25  1 49  155 149 255
;CH25  2 49  155 149 255
;CH25  3 89  155 189 255

i1[1,*,0]=[104,49,49,89]
i1[1,*,1]=[204,149,149,189]
i2[1,*,0]=[155,155,155,155]
i2[1,*,1]=[255,255,255,255]

;CH26  0 93  155 193 255
;CH26  1 48  155 148 255
;CH26  2 53  155 153 255
;CH26  3 105 155 205 255

i1[2,*,0]=[93,48,53,105]
i1[2,*,1]=[193,148,153,205]
i2[2,*,0]=[155,155,155,155]
i2[2,*,1]=[255,255,255,255]

;CH27  0 128 130 228 230
;CH27  1 94  155 194 255
;CH27  2 97  134 197 234
;CH27  3 78  155 178 255

i1[3,*,0]=[128,94,97,78]
i1[3,*,1]=[228,194,197,178]
i2[3,*,0]=[130,155,134,155]
i2[3,*,1]=[230,255,234,255]

;CH28  0 100 130 200 230
;CH28  1 67  138 167 238
;CH28  2 77  142 177 242
;CH28  3 53  125 153 225

i1[4,*,0]=[100,67,77,53]
i1[4,*,1]=[200,167,177,153]
i2[4,*,0]=[130,138,142,125]
i2[4,*,1]=[230,238,242,225]


n_points = 11. ; N_points in currents for all RCAs

;; JUST FOR TESTING WITH SOVT2 DATA

 ; i1[*,*,0] = 200
 ; i1[*,*,1] = 210
 ; i2 = i1

;-----------------------
; Cicle over RCA

  for k = 28, 28  do begin


  horn_id = '#'+ strtrim(string(k),2)
  print,'NOW ANALYSING RCA ', horn_id
  feed_horn = horn_id


  dummy_index=' '


; Cicle over phase_switches ACA

    for j=1,1 do begin
```

```
    fem_arm = lama_fem_tql_correspondence(feed_horn, j)
    print,'NOW ANALYSING ACA ', fem_arm

;; SELECT TIME WINDOW FOR THE TEST
   ;   time_window = [1618043503.7d0, 1618082654.6d0]

     cpv = pegaso_tune_phase_switch_currents(j, time_window, feed_horn=feed_horn,$
                                             time_crop=time_crop, time_delay = time_delay, time_offset=time_offset,$
                                             proc_type = proc_type)


;; result - structure variable containing all the information for the report
;;    result.test_name - the name of the test
;;      result.fem_arm -   e.g. M1, M2, S1, S2
;;    result.fh - the feed_horn
;;    result.channel - phase_switch_ID
;;    result.sci_ch - science channel
;;    result.time_window - the trigger time window
;;    result.time_windows - the current time windows
;;    result.i1_av - The average I1 values for each time window
;;    result.i2_av - The average I2 values for each time window
;;    result.i1_opt - Value of I1 at optimum
;;      result.i2_opt - Value of I2 at optimum
;;    result.v1even - the averages for the V1 even values
;;    result.v1odd - the averages for the V1 odd values
;;    result.v2even - the averages for the V2 even values
;;    result.v2odd - the averages for the V2 odd values
;;      result.dV1 - difference (V1even - V1odd)
;;    result.dV2 - Difference (V2even - V2odd)
;;    result.dV   - Sqrt(dV1^2 + dV2^2)
;;      result.dV_min - value of dV at optimum (minimum)
;;    result.messages - any warning messages generated


;; Check if data is present

check_result = size(cpv)

if check_result[2] ne 8  then begin
     print,'SKIP THE ANALYSIS
     goto, skip
endif


len = n_elements(cpv.i1_av)
cpv_data = dblarr(11,len)

cpv_data[0,*] = cpv.i1_av
cpv_data[1,*] = cpv.i2_av
cpv_data[2,*] = cpv.v1even
cpv_data[3,*] = cpv.v1odd
cpv_data[4,*] = abs(cpv.dV1)
cpv_data[5,*] = cpv.v2even
cpv_data[6,*] = cpv.v2odd
cpv_data[7,*] = abs(cpv.dV2)
cpv_data[8,*] = cpv.dV
cpv_data[9:10,*] = cpv.time_windows+time_offset

;; EXPORT RAW DATA INTO A TXT FILE

exportdir = get_sessiondir(caller)+ $
            get_localdir(caller, 'tune') + $
            path_sep()

;; DEFINE FILENAMES
   root = 'CPV_PSW_tuning_raw_'
   feed = 'LFI'+strtrim(string(k),2)+'_'

exportfiledat = root+feed+fem_arm+'.csv'

save, cpv, cpv_data, filename=exportdir+root+feed+fem_arm+'.save'

file_header_raw = ['I1,', 'I2,', 'V1even,', 'V1odd,', 'DV1,', 'V2even,', 'V2odd,', 'DV2,', 'DV,', 'T0, ','T1']

get_lun, Unit
openw,Unit,exportdir + exportfiledat
 printf,Unit, file_header_raw
;; THIS LOOP IS FOR THE 'FORMAT' ONLY
```

```
for i = 0, len-1  do begin
    printf,Unit, cpv_data[*,i],format='(2(I3,","), 7(E20.7 ,","), 2(F20.2, :,","))'
endfor
close,Unit
free_lun, Unit

;; GRAB THE DATA WE NEED FOR ANALYSIS: EXCLUDE UNWATED VALUES (LIKE 0,0) AND ERASE DUPLICATED
;; CURRENT PAIRS ON THE BASIS OF THE DEFINED GRID FOR THE TEST

step_x = (i1[k-24,j,1] - i1[k-24,j,0])/(n_points-1)
step_y = (i2[k-24,j,1] - i2[k-24,j,0])/(n_points-1)

grid_x = findgen(n_points)*step_x + i1[k-24,j,0]
grid_y = findgen(n_points)*step_x + i2[k-24,j,0]

crop = dblarr(9,n_points*n_points)

index=0

for ii = 0,n_points-1 do begin
     for jj=0,n_points-1 do begin
         grab = where(cpv_data[0,*] eq grid_x[ii] and cpv_data[1,*] eq grid_y[jj])
         if grab[0] eq -1 then begin
            print,'ERROR FOUND! CHECK THE PROCEDURE AND THE I1 and I2 VALUES at'
            print,grid_x[ii], grid_y[jj]
            print,'FOR RCA', feed_horn, 'and ACA', fem_arm
            goto, skip
         endif else begin

               if n_elements(grab) gt 2 then begin

               crop[0,index] = grid_x[ii]
               crop[1,index] = grid_y[jj]
               crop[2,index] = cpv_data[2,grab[2]]
               crop[3,index] = cpv_data[3,grab[2]]
               crop[4,index] = cpv_data[4,grab[2]]
               crop[5,index] = cpv_data[5,grab[2]]
               crop[6,index] = cpv_data[6,grab[2]]
               crop[7,index] = cpv_data[7,grab[2]]
               crop[8,index] = cpv_data[8,grab[2]]

               endif else begin

               crop[0,index] = grid_x[ii]
               crop[1,index] = grid_y[jj]
;               crop[2,index] = mean(cpv_data[2,grab])
;               crop[3,index] = mean(cpv_data[3,grab])
;               crop[4,index] = mean(cpv_data[4,grab])
;               crop[5,index] = mean(cpv_data[5,grab])
;               crop[6,index] = mean(cpv_data[6,grab])
;               crop[7,index] = mean(cpv_data[7,grab])
;               crop[8,index] = mean(cpv_data[8,grab])
               crop[0,index] = grid_x[ii]
               crop[1,index] = grid_y[jj]
               crop[2,index] = cpv_data[2,grab[0]]
               crop[3,index] = cpv_data[3,grab[0]]
               crop[4,index] = cpv_data[4,grab[0]]
               crop[5,index] = cpv_data[5,grab[0]]
               crop[6,index] = cpv_data[6,grab[0]]
               crop[7,index] = cpv_data[7,grab[0]]
               crop[8,index] = cpv_data[8,grab[0]]

               endelse
               endelse

         index = index+1


endfor
     endfor


file_header = ['I1,', 'I2,', 'V1even,', 'V1odd,', 'DV1,', 'V2even,', 'V2odd,', 'DV2,', 'DV']

   root = 'CPV_PSW_tuning_'
   feed = 'LFI'+strtrim(string(k),2)+'_'

exportfiledat =  root+feed+fem_arm+'.csv'

get_lun, Unit
```

```
openw,Unit,exportdir + exportfiledat
 printf,Unit, file_header
;; THIS LOOP IS FOR THE 'FORMAT' ONLY
for i = 0, n_elements(crop[0,*])-1  do begin
    printf,Unit, crop[*,i],format='(2(I3,","), 7(E20.7 ,:, ","))'
endfor
close,Unit
free_lun, Unit


;;; PLOTTING

!P.MULTI=[0,2,2,0,0]


exportfileps = root+feed+fem_arm+'.ps'
set_plot,'ps'
device,/color,filename=exportdir+exportfileps

loadct,13

;; DEFINE TITLES
xtitle = 'I1 [DEC]'
ytitle = 'I2[DEC]'
title = 'CPV PSW Tuning LFI '+feed_horn +' '+ fem_arm

x = reform(crop[0,*])
y = reform(crop[1,*])
z = reform(crop[8,*])
z1 = reform(crop[4,*])
z2 = reform(crop[7,*])


 opt = where(z eq min(z))
 opt1 = where(z1 eq min(z1))
 opt2 = where(z2 eq min(z2))

    cpv_i1_opt = x[opt]
    cpv_i2_opt = y[opt]

    cpv_i1_opt1 = x[opt1]
    cpv_i2_opt1 = y[opt1]

    cpv_i1_opt2 = x[opt2]
    cpv_i2_opt2 = y[opt2]


contour, z,x,y,/irregular,/isotropic, $
title = title + '- Sqrt[(dV1)^2+(dV2)^2]', $
xtitle=xtitle,$
ytitle=ytitle, charsize=0.5,$
subtitle = 'optimal at [I1,I2]= ['+strtrim(string(long(cpv_i1_opt)),2)+ $
                                  ','+strtrim(string(long(cpv_i2_opt)),2) + ']',$
xrange=[min(x),max(x)], yrange=[min(y),max(y)],/xstyle,/ystyle,$
/fill, nlevels=255

oplot,[cpv_i1_opt,cpv_i1_opt],[0.,300.]
oplot,[0.,300.],[cpv_i2_opt,cpv_i2_opt]


contour, z1,x,y,/irregular,/isotropic, $
title = title + '- dV1', $
xtitle=xtitle, $
ytitle=ytitle,charsize=0.5,$
subtitle = 'optimal at [I1,I2]= ['+strtrim(string(long(cpv_i1_opt1)),2)+ $
                                  ','+strtrim(string(long(cpv_i2_opt1)),2) + ']',$
xrange=[min(x),max(x)], yrange=[min(y),max(y)],/xstyle,/ystyle,$
/fill, nlevels=255


oplot,[cpv_i1_opt1,cpv_i1_opt1],[0.,300.]
oplot,[0.,300.],[cpv_i2_opt1,cpv_i2_opt1]

contour, z2,x,y,/irregular,/isotropic, $
title = title + '- dV2', $
xtitle=xtitle, $
ytitle=ytitle,charsize=0.5,$
subtitle = 'optimal values at [I1,I2]= ['+strtrim(string(long(cpv_i1_opt2)),2)+ $
                                  ','+strtrim(string(long(cpv_i2_opt2)),2) + ']',$
xrange=[min(x),max(x)], yrange=[min(y),max(y)],/xstyle,/ystyle,$
/fill, nlevels=255
```

```
oplot,[cpv_i1_opt2,cpv_i1_opt2],[0.,300.]
oplot,[0.,300.],[cpv_i2_opt2,cpv_i2_opt2]


plot,z,title=title+'- Sqrt[(dV1)^2+(dV2)^2]',$
subtitle = 'optimal values at Index= ['+strtrim(string(long(where(z eq min(z)))),2)+']',$
charsize=0.5,$
psym = 1, symsize=0.5

;; DRAW FILLED CIRCLE
;A = FINDGEN(17) * (!PI*2/16.)
;USERSYM, COS(A), SIN(A), /FILL


;; PLOTTING SURFACES

exportfilesurfps = root+feed+fem_arm+'_surf.ps'
set_plot,'ps'
device,/color,filename=exportdir+exportfilesurfps

loadct,0

step_x = (i1[k-24,j,1] - i1[k-24,j,0])/(n_points-1)
step_y = (i2[k-24,j,1] - i2[k-24,j,0])/(n_points-1)

xs = Findgen(n_points)*step_x + i1[k-24,j,0]
ys = Findgen(n_points)*step_y + i2[k-24,j,0]

triangulate,x,y,Triangles

zs = Trigrid(x,y,z, Triangles,[10.,10.])
z1s = Trigrid(x,y,z1, Triangles,[10.,10.])
z2s = Trigrid(x,y,z2, Triangles,[10.,10.])

surface,zs,xs,ys, title = title + '- Sqrt[(dV1)^2+(dV2)^2]', $
xtitle=xtitle, $
ytitle=ytitle

surface,z1s,xs,ys, title = title + '- dV1', $
xtitle=xtitle, $
ytitle=ytitle
surface,z2s,xs,ys, title = title + '- dV2', $
xtitle=xtitle, $
ytitle=ytitle

plot,z,title=title+'- Sqrt[(dV1)^2+(dV2)^2]',$
subtitle = 'optimal values at Index= ['+strtrim(string(long(where(z eq min(z)))),2)+']',$
charsize=0.5,$
psym = 1, symsize=0.5

device,/close

set_plot,'x' ; Substitute with 'x' in case of Linux and MacOSx operating systems.
!P.MULTI=0

skip: print, 'CHECK THE DATA. SOME DATA MAY BE MISSED'

    endfor
  endfor

end
```

--- END  OF THE DOCUMENT ---