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Authors	BATTAGLIA, Paola Maria, Bersanelli, Marco, CUTTAIA, FRANCESCO, Davis, Richard, Wilkinson, Althea, FRAILIS, Marco, Franceschet, Cristian, FRANCESCHI, ENRICO, GALEOTTA, Samuele, GREGORIO, Anna, Leonardi, Rodrigo, Lowe, Stuart, MARIS, Michele, Meinhold, Peter, Mendes, Luis, MENNELLA, ANIELLO, Poutanen,Torsti, SANDRI, MAURA, TAVAGNACCO, Daniele, TERENZI, LUCA, Tomasi, Maurizio, VILLA, Fabrizio, ZACCHEI, Andrea, Zonca, Andrea
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TITLE:	**Planck-LFI CPV: Phase Switch tuning and verification** (P_PVP_LFI_0004_01, P_PVP_LFI_0004_02)

DOC. TYPE:	**Test Report**		
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Prepared by	**The Planck-LFI calibration team**	**Date:** **Signature:**	October, 2009 [signature]
Agreed by	**C. BUTLER** **LFI Program Manager**	**Date:** **Signature:**	October, 2009 [signature]
Approved by	**N. MANDOLESI** **LFI Principal Investigator**	**Date:** **Signature:**	October, 2009 [signature]

The Planck-LFI calibration team

- Paola Battaglia (SCOS/TQL operator)
- Marco Bersanelli (LFI instrument scientist, test leader)
- Francesco Cuttaia (CPV responsible, test leader)
- Richard Davis (30/44 GHz data analysis)
- Althea Wilkinson (30/44 GHz data analysis)
- Marco Frailis (Level 1 manager)
- Cristian Franceschet (SCOS/TQL operator)
- Enrico Franceschi (GSE manager)
- Samuele Galeotta (LIFE/PEGASO development)
- Anna Gregorio (Instrument Operation Manager)
- Rodrigo Leonardi (data analysis)
- Stuart Lowe (LIFE/PEGASO development)
- Michele Maris (data analysis, LIFE/PEGASO development)
- Peter Meinhold (Test leader, data analysis)
- Luis Mendes (data analysis)
- Aniello Mennella (Calibration Scientist, test leader)
- Torsti Poutanen (data analysis)
- Maura Sandri (Test leader, data analysis)
- Daniele Tavagnacco (SCOS/TQL operator)
- Luca Terenzi (Tests leader, data analysis and LIFE/PEGASO development)
- Maurizio Tomasi (Test leader, data analysis and LIFE/PEGASO development)
- Fabrizio Villa (Test leader, data analysis)
- Andrea Zacchei (LFI DPC manager)
- Andrea Zonca (SCOS/TQL operator, LIFE/PEGASO development)

DISTRIBUTION LIST

M. BERSANELLI	UNIMI – Milano	marco.bersanelli@mi.infn.it	Yes
R.C. BUTLER	INAF/IASF – Bologna	butler@iasfbo.inaf.it	Yes
F. CUTTAIA	INAF/IASF – Bologna	cuttaia@iasfbo.inaf.it	Yes
A. GREGORIO	UniTs – Trieste	Anna.gregorio@ts.infn.it	Yes
D. MAINO	UNIMI – Milano	davide.maino@mi.infn.it	Yes
N. MANDOLESI	INAF/IASF – Bologna	mandolesi@iasfbo.inaf.it	Yes
A. MENNELLA	UNIMI – Milano	aniello.mennella@fisica.unimi.it	Yes
A. ZACCHEI	INAF/OATs – Trieste	zacchei@oats.inaf.it	Yes
G. GUYOT	IAS - Orsay	guy.guyot@ias.u-psud.fr	Yes
J.M. LAMARRE	IAS - Orsay	lamarre@ias.u-psud.fr	Yes
F. PAJOT	IAS - Orsay	francois.pajot@ias.u-psud.fr	Yes
J.L. PUGET	IAS - Orsay	puget@ias.u-psud.fr	Yes
L. VIBERT	IAS - Orsay	laurent.vibert@ias.u-psud.fr	Yes
D. DEXIER	ESA - ESAC	damien.texier@sciops.esa.int	Yes
S. FOLEY	ESA - ESOC	Steve.Foley@esa.int	Yes
R. LAUREIIS	ESA - PSO	rlaureij@rssd.esa.int	Yes
L. MENDES	ESA - PSO	lmendes@rssd.esa.int	Yes
J. TAUBER	ESA- PSO	jtauber@rssd.esa.int	Yes
C. WATSON	ESA - ESOC	Christopher.J.Watson@esa.int	Yes
LFI Core team coordinators		lfi_ctc@iasfbo.inaf.it	Yes
LFI radiometer core team		planck_cta02@fisica.unimi.it	Yes
LFI calibration team			
LFI System PCC	INAF/IASF – Bologna	lfispcc@iasfbo.inaf.it	Yes

CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
1.0	05 Oct. 09	All	First Issue	CPV completion Review Meeting

TABLE OF CONTENTS

1 ACRONYMS

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

2 APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable Documents

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

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

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

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

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

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

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

2.2 Reference Documents

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

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

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

[RD4] Villa, F. (2008), Planck LFI TV Test @ CSL: Phase Switch Matrix Tuning Guide.

3 Introduction

This document describes the activities performed during the first phase switch (PSW) tuning and verification test performed during CPV.

The objective of this test, composed by two steps, 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 first part of the test (P_PVP_LFI_0004_01, namely tuning) was performed before the tuning of the front-end modules amplifiers. The second part (P_PVP_LFI_0004_02, namely verification) was performed after the tuning of the front-end modules to verify the impact on phase switch balancing of different amplifiers biases.

The test was performed only on 30 and 44GHz RCAs as planned. Details of the test concept are reported in [RD4].

4 PSW Tuning: Test Execution

4.1 Test configuration

The test configuration is the following

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

LFI Personnel involved during the test is:

LFI Instrument Operation Manager	Anna Gregorio (UniTs anna.gregorio@ts.infn.it)
LFI Calibration Scientist	Aniello Mennella (UniMi aniello.mennella@fisica.unimi.it)
LFI CPV Manager	Francesco Cuttaia (IASF-BO cuttaia@iasfbo.inaf.it)
Test leader	Fabrizio Villa (IASF-BO villa@iasfbo.inaf.it)
LFI IOT	Anna Gregorio, Francesco Cuttaia, Aniello Mennella, Marco Frailis, Samuele Galeotta, Andrea Zacchei, Maurizio Tomasi, Althea Wilkinson, Peter Meinhold, Richard Davis, Daniele Tavagnacco
Industry support	Paola Battaglia

4.2 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 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)					

4.3 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*

Figure 2.

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.

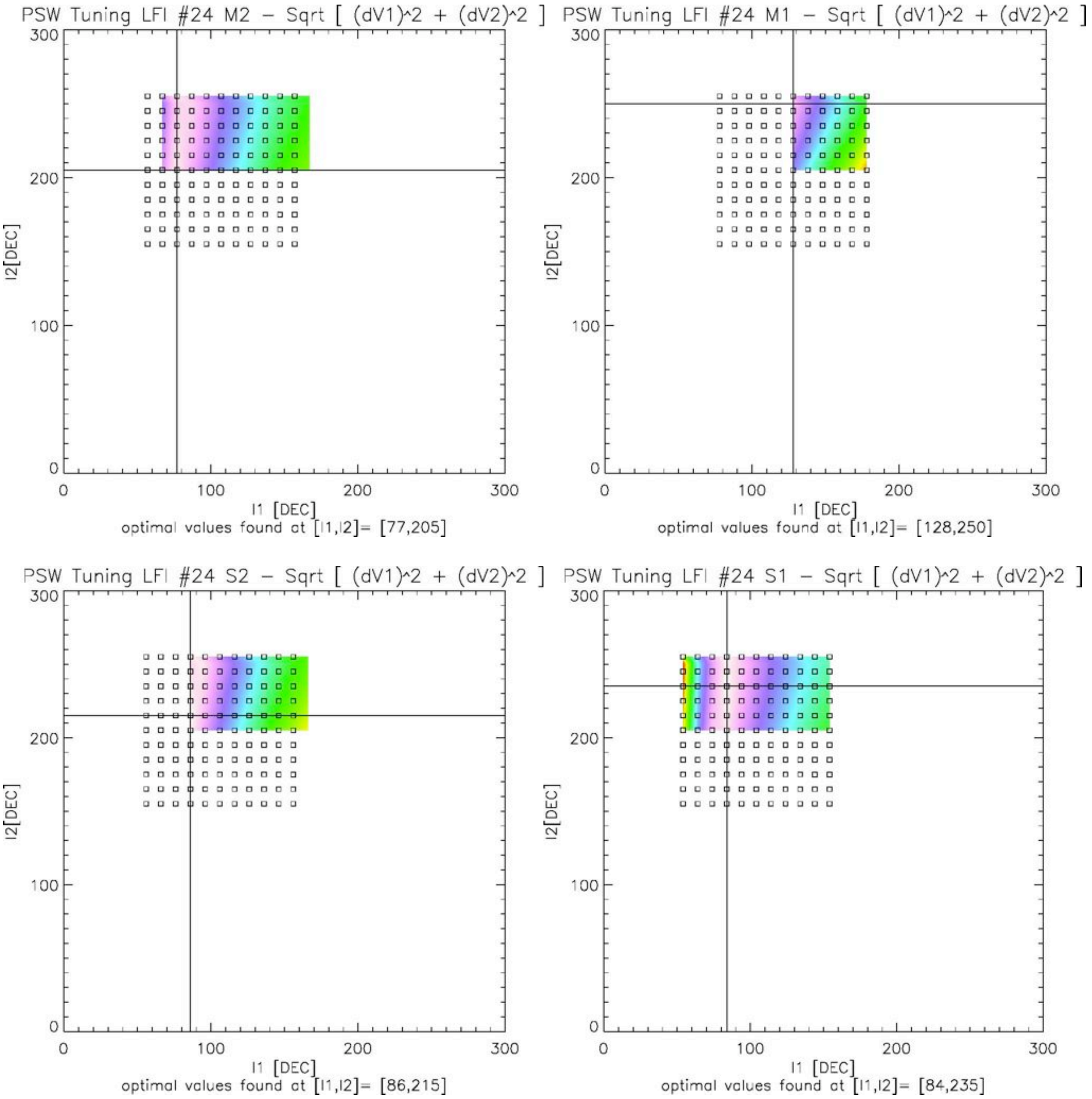


Figure 3: RCA24 Grid Definition. The coloured contour plot area is the CSL phase switch tuning test. The black grid is the new grid definition for the CPV.

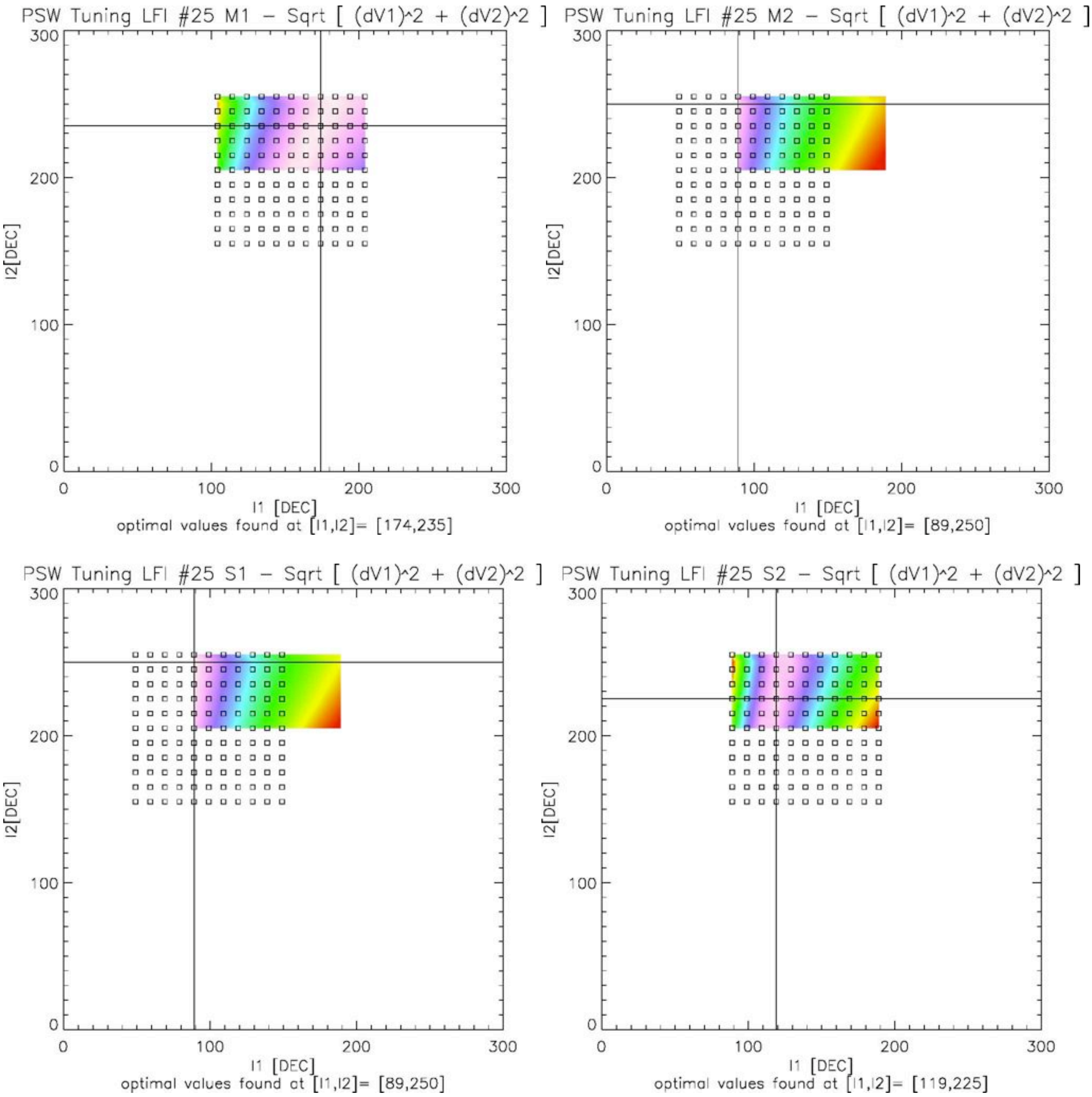


Figure 4: RCA25 Grid Definition. The coloured contour plot area is the CSL phase switch tuning test. The black grid is the new grid definition for the CPV.

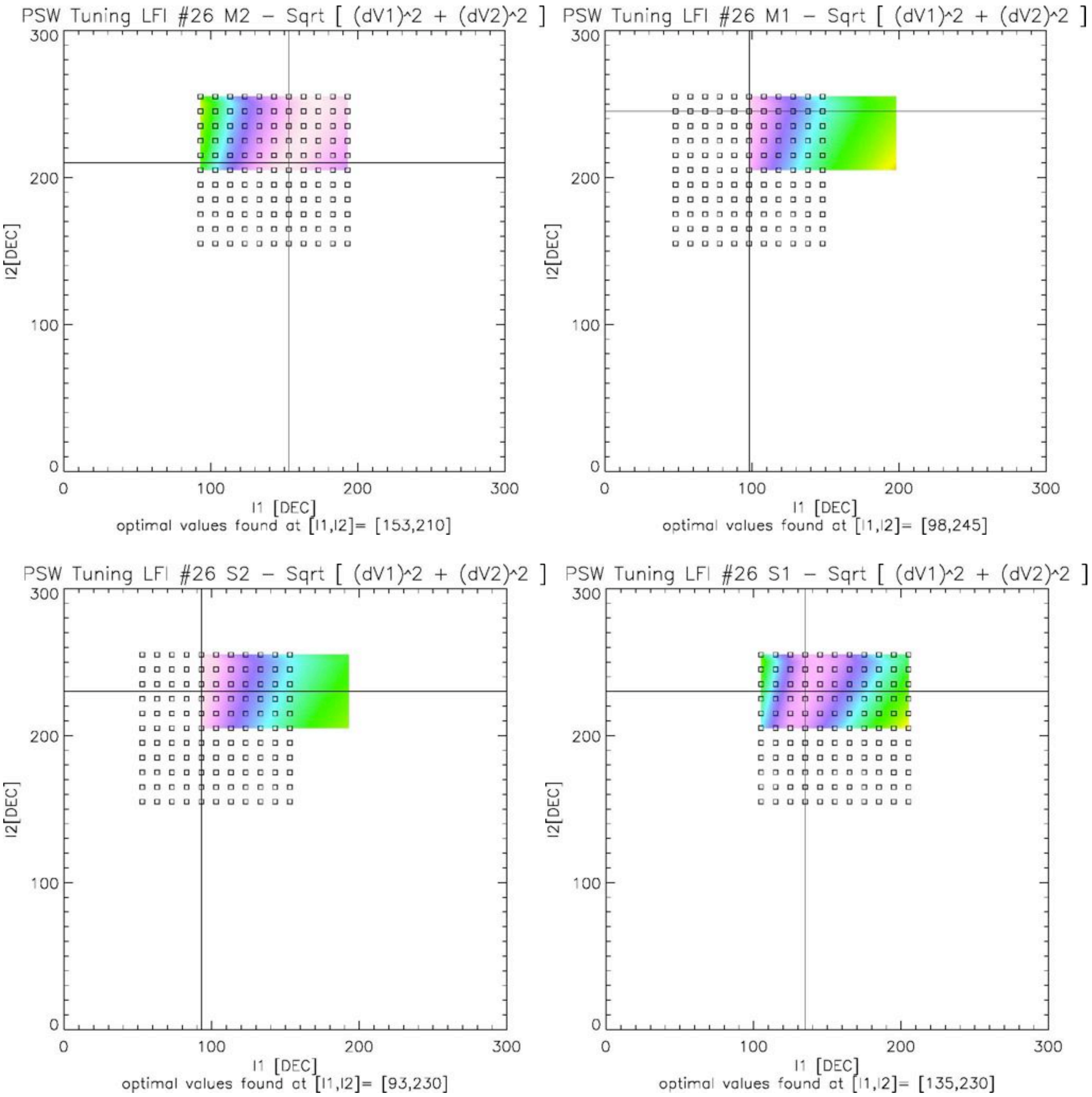


Figure 5: RCA26 Grid Definition. The coloured contour plot area is the CSL phase switch tuning test. The black grid is the new grid definition for the CPV.

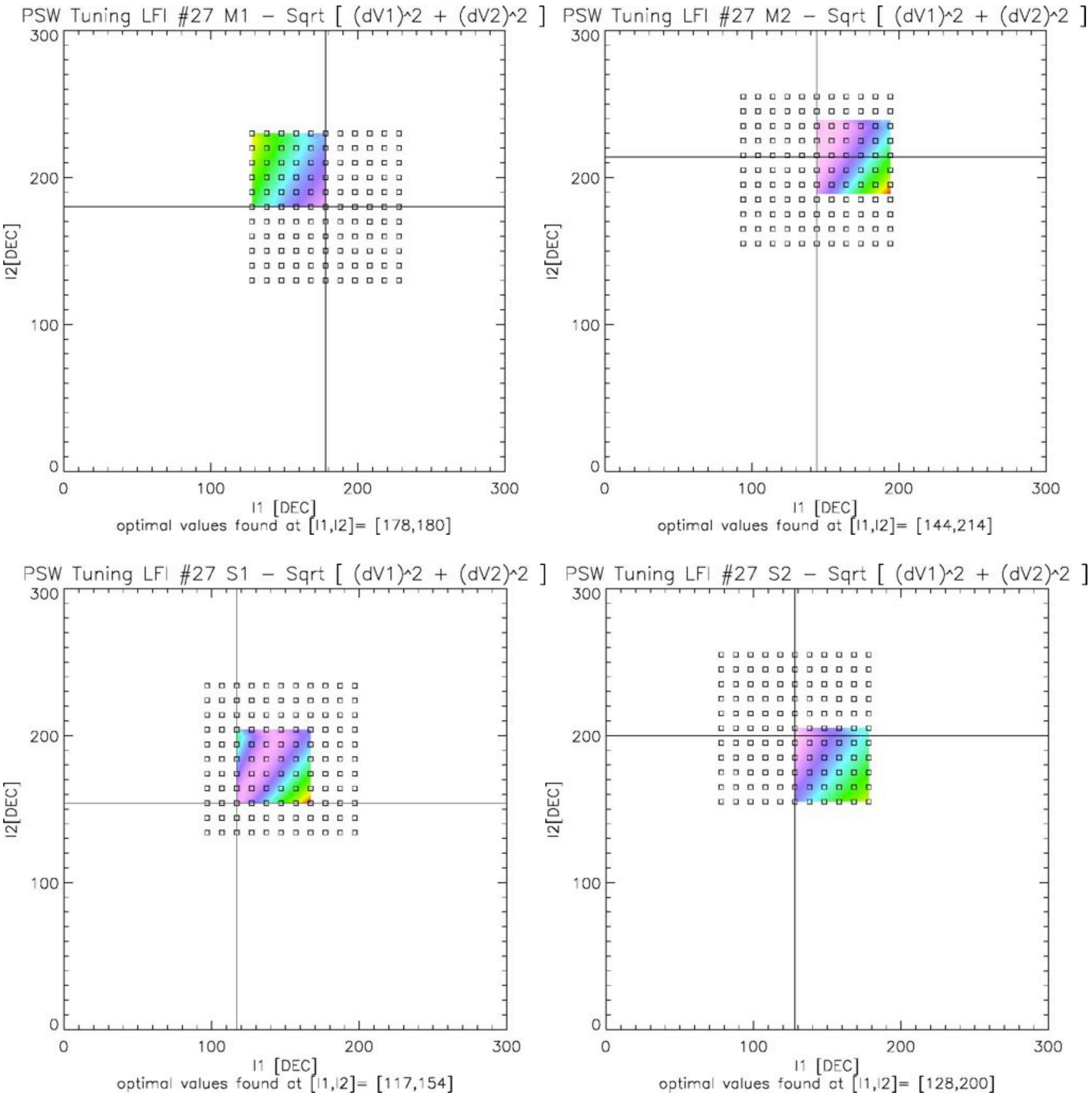


Figure 6: RCA27 Grid Definition. The coloured contour plot area is the CSL phase switch tuning test. The black grid is the new grid definition for the CPV.

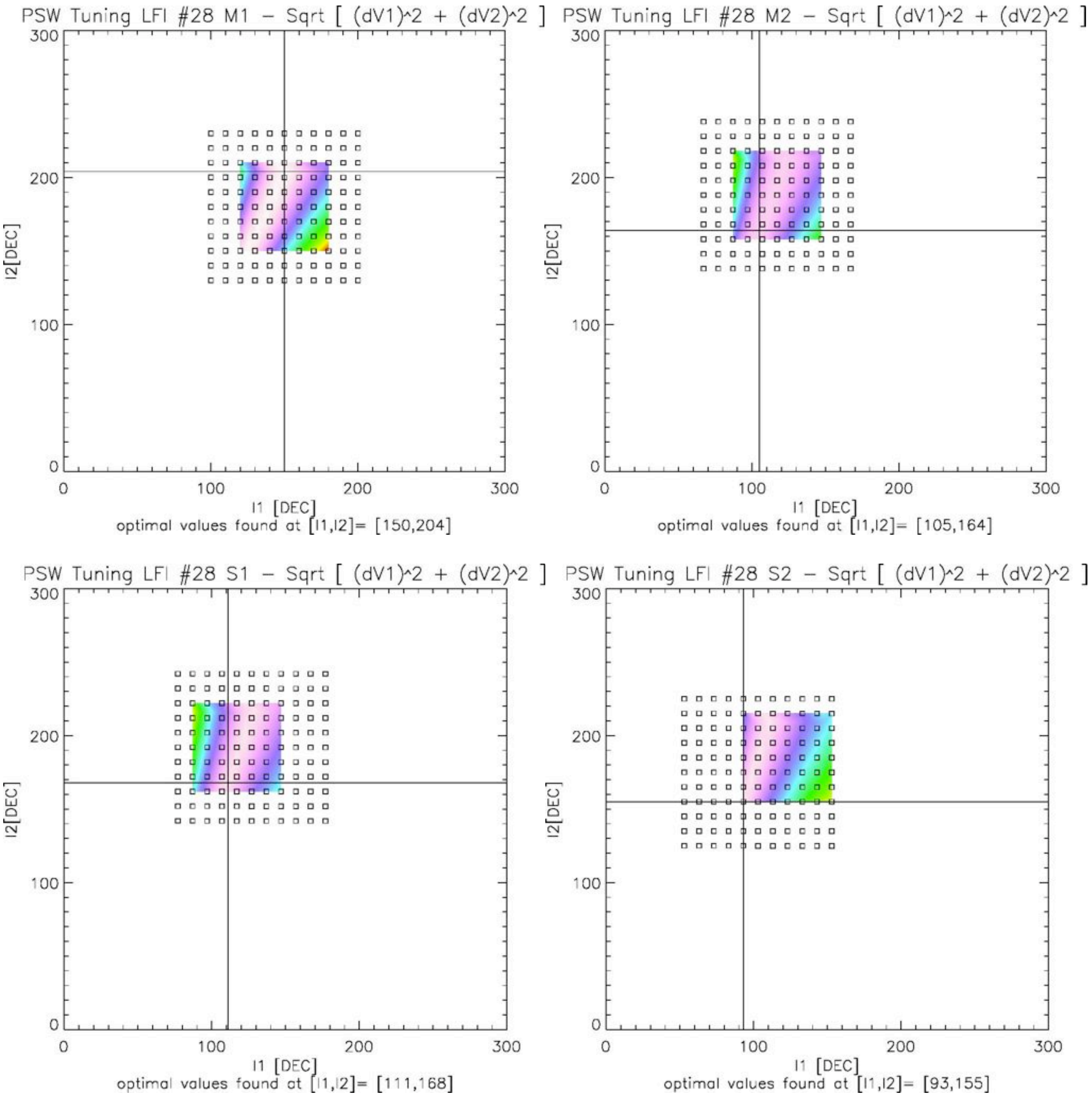


Figure 7: RCA28 Grid Definition. The coloured contour plot area is the CSL phase switch tuning test. The black grid is the new grid definition for the CPV.

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.

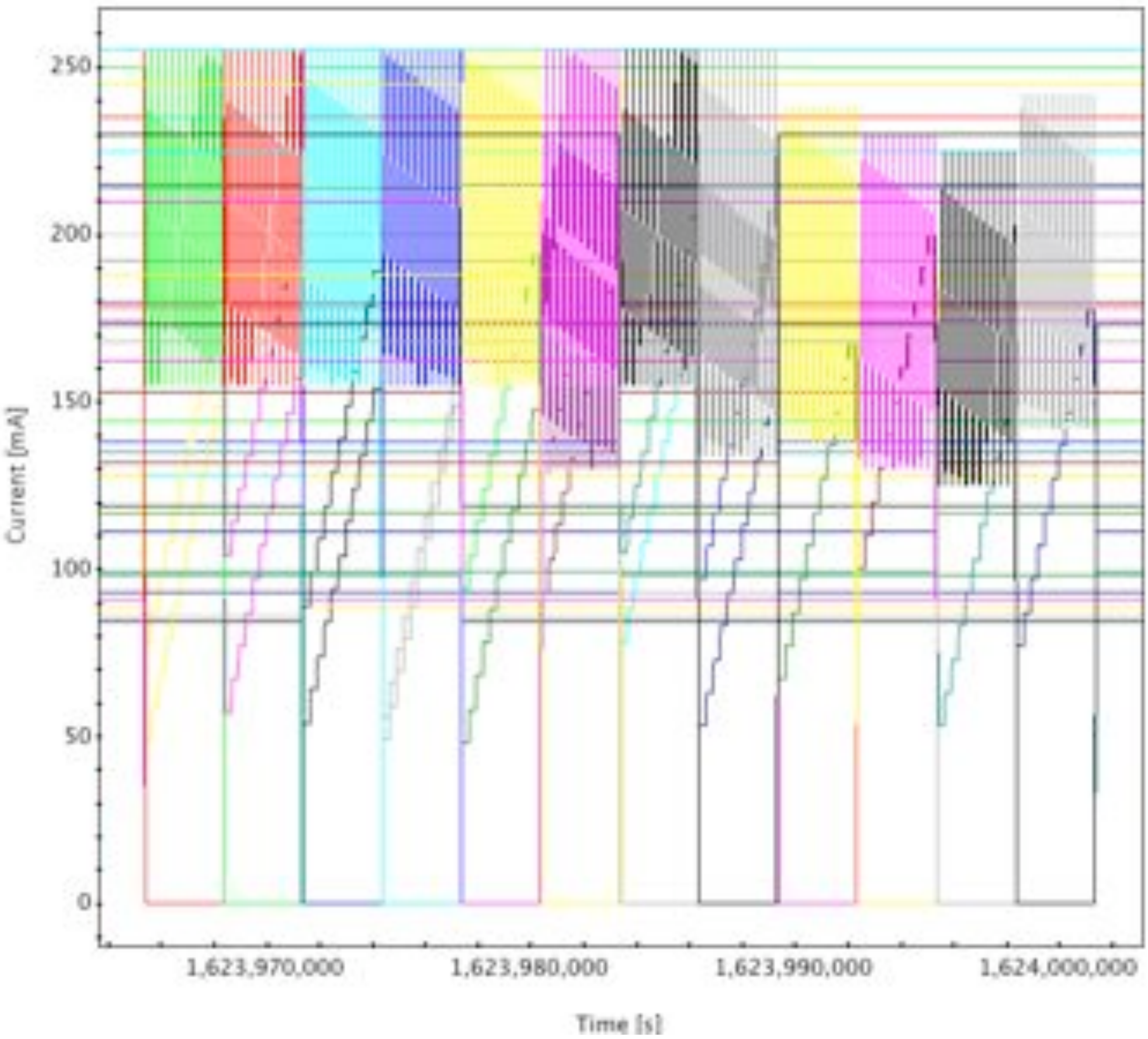


Figure 8. I1 and I2 current values as plotted in pegaso_view

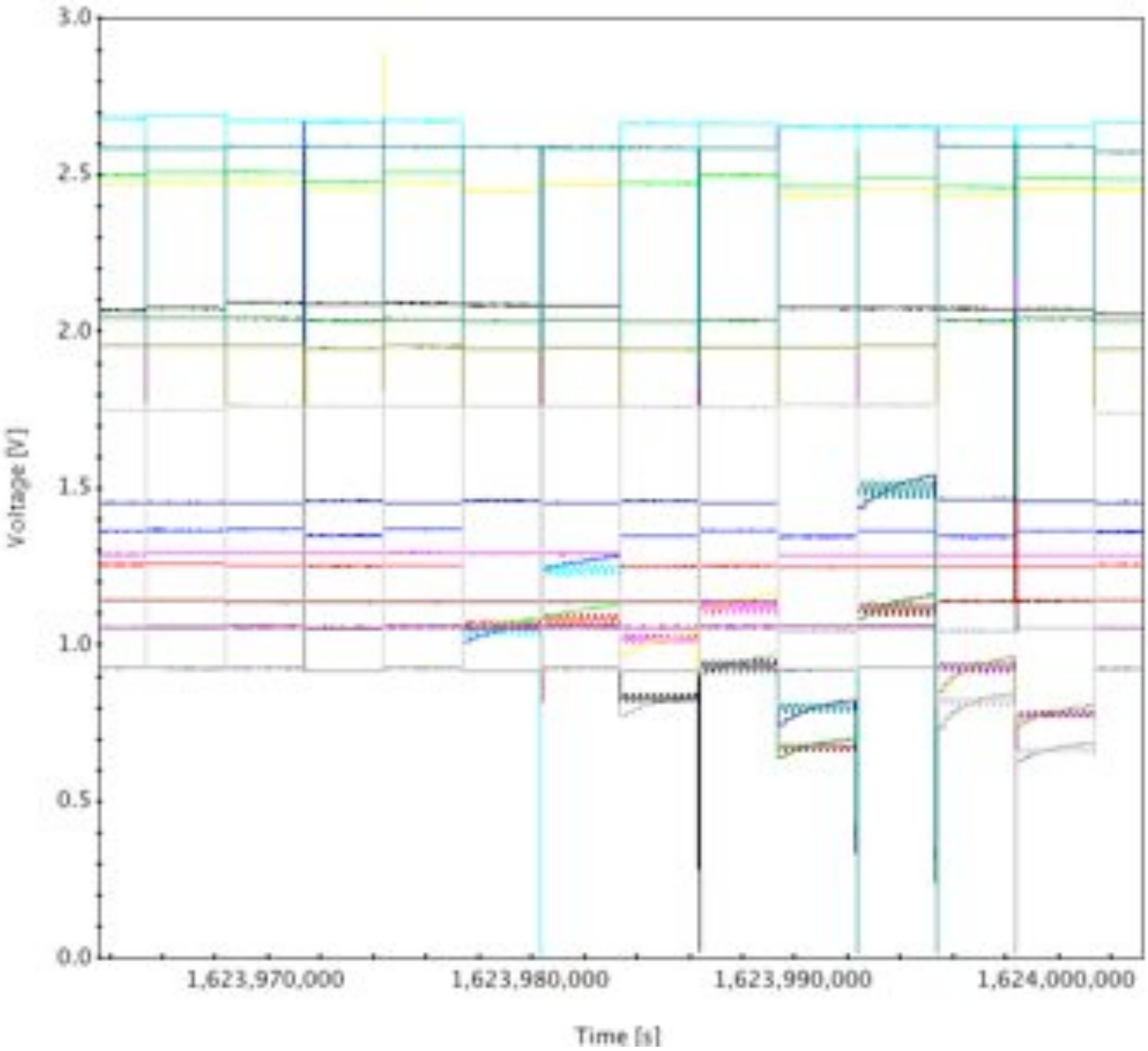


Figure 9. Output radiometer voltages as plotted in pegaso_view for the 30 GHz RCA phase switches tuning

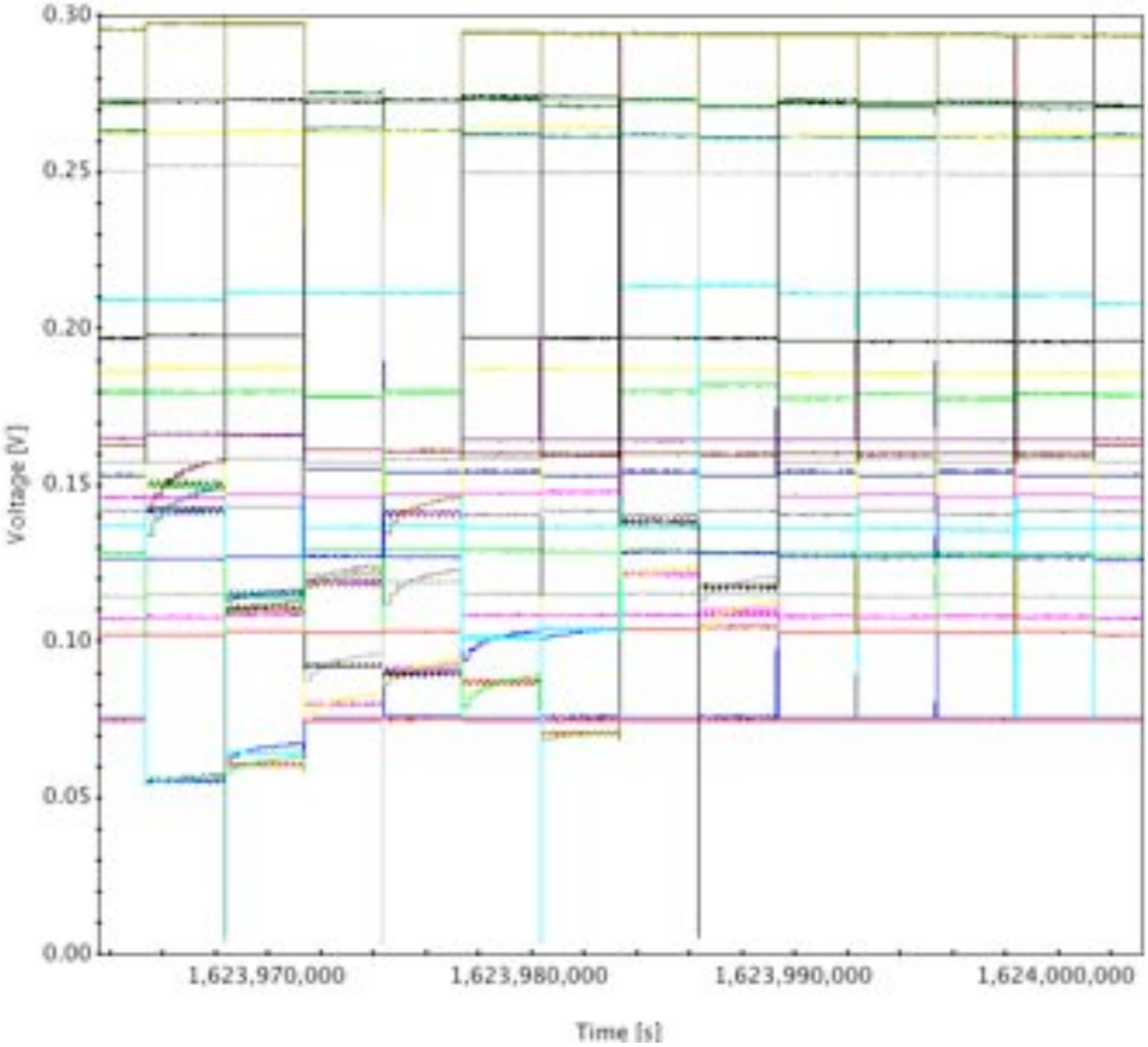


Figure 10. Output radiometer voltages as plotted in pegaso_view for the 30 GHz RCA phase switches tuning

5 PSW 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.

5.1 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
ΔV_1 defined as $\Delta V_1 = V_1^{(even)} - V_1^{(odd)}$
$V_1^{(even)}$: 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
ΔV_2: defined as $\Delta V_2 = V_2^{(even)} - V_2^{(odd)}$
ΔV: 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

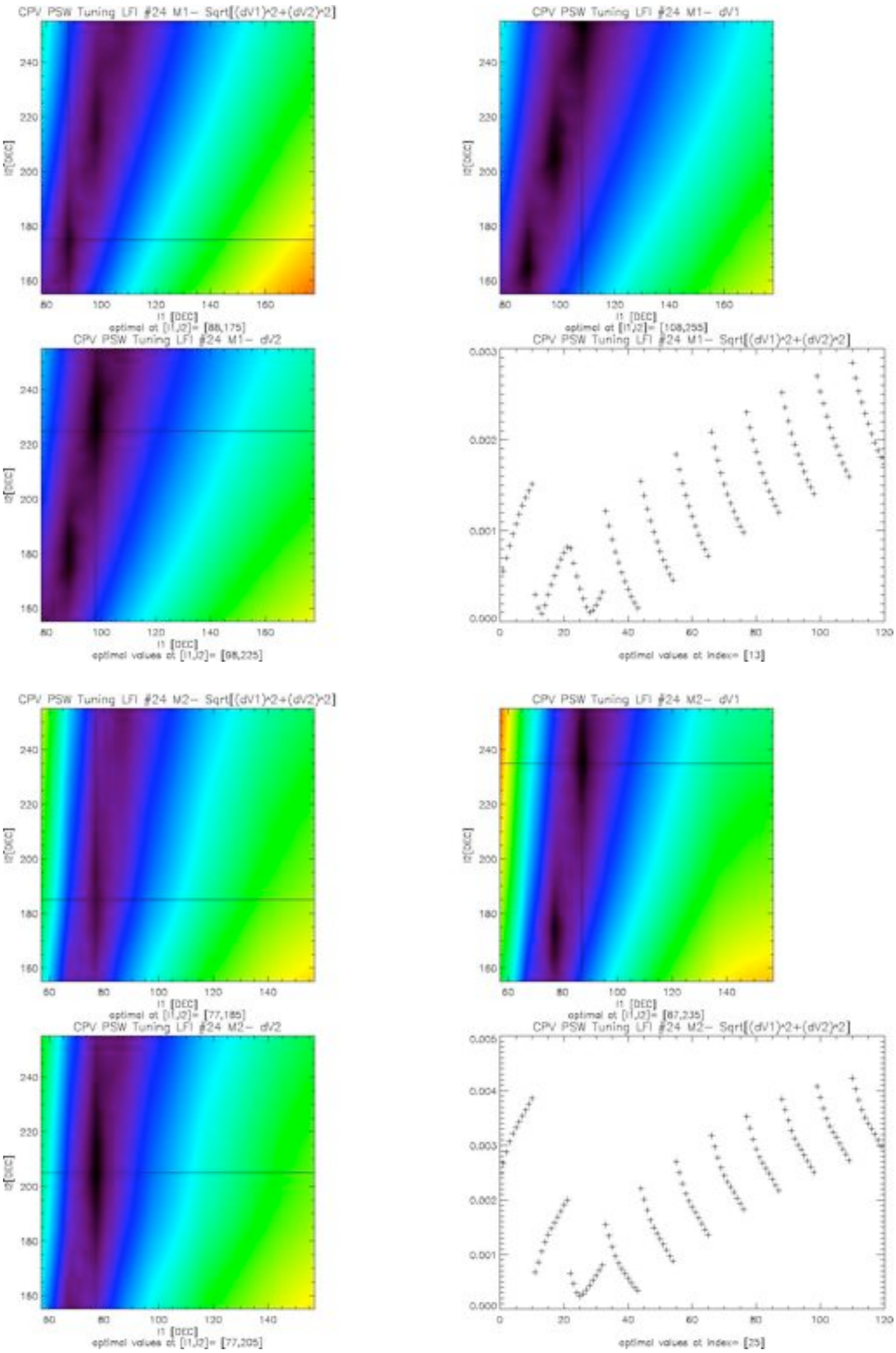
this file contains the same information of the above file but for 121 points (11x11) for each phase switch as required by the procedure. The time information has not recorded in this file since it was created mainly for plotting the results. The graphical output is stored in the following files:

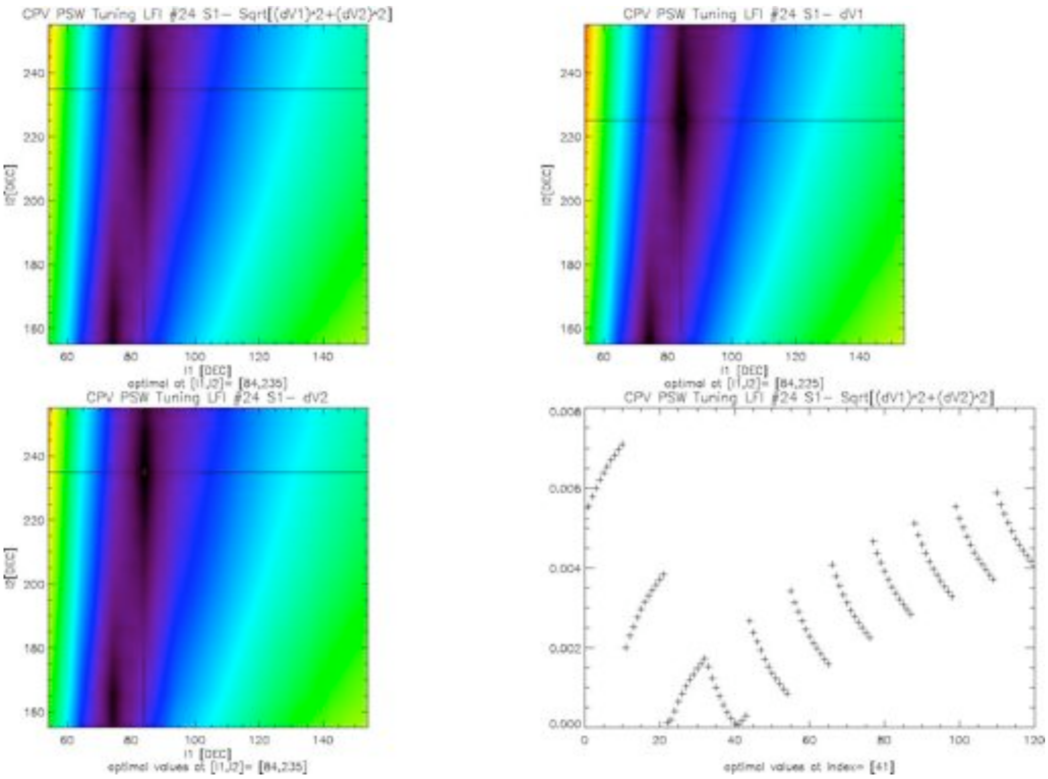
`CPV_PSW_tuning_LFI24_M1.ps`
containing the contour plot graphical output of ΔV , ΔV_1, and ΔV_2 .

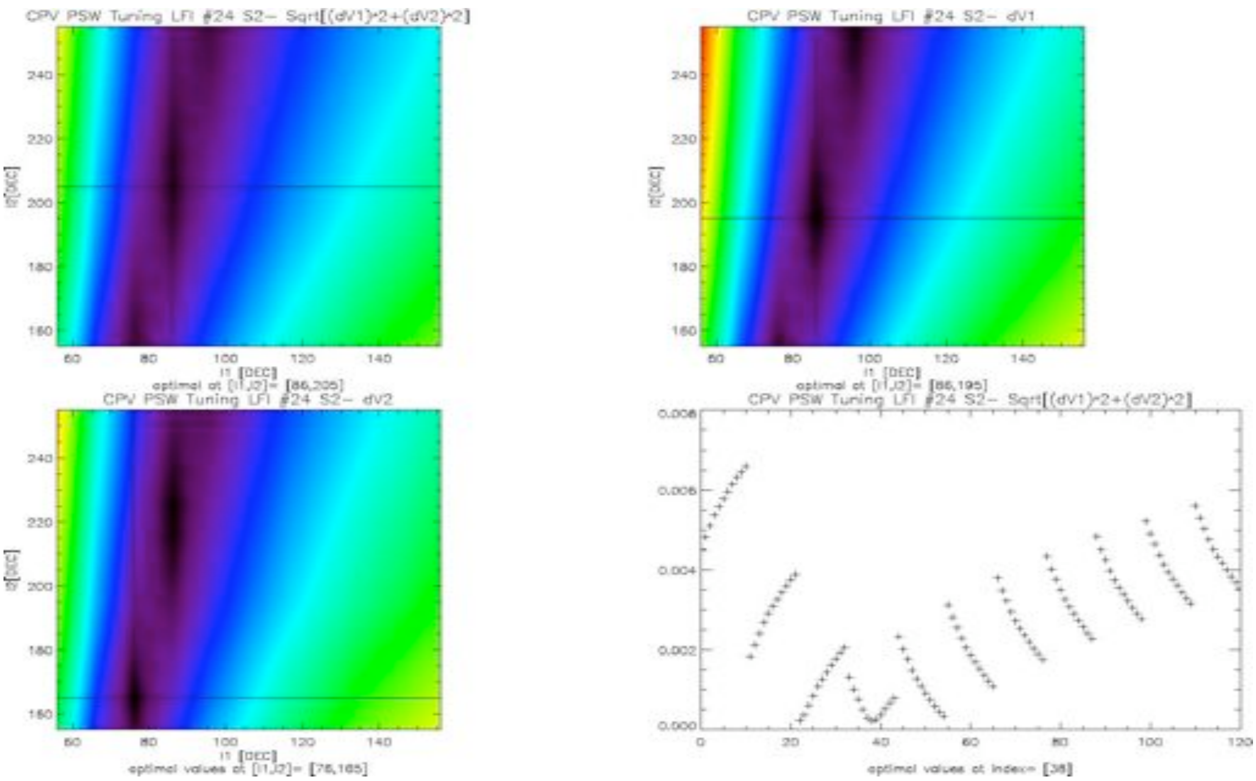
`CPV_PSW_tuning_LFI24_M1_surf.ps`
containing the surface plot graphical output of ΔV , ΔV_1, and ΔV_2 .

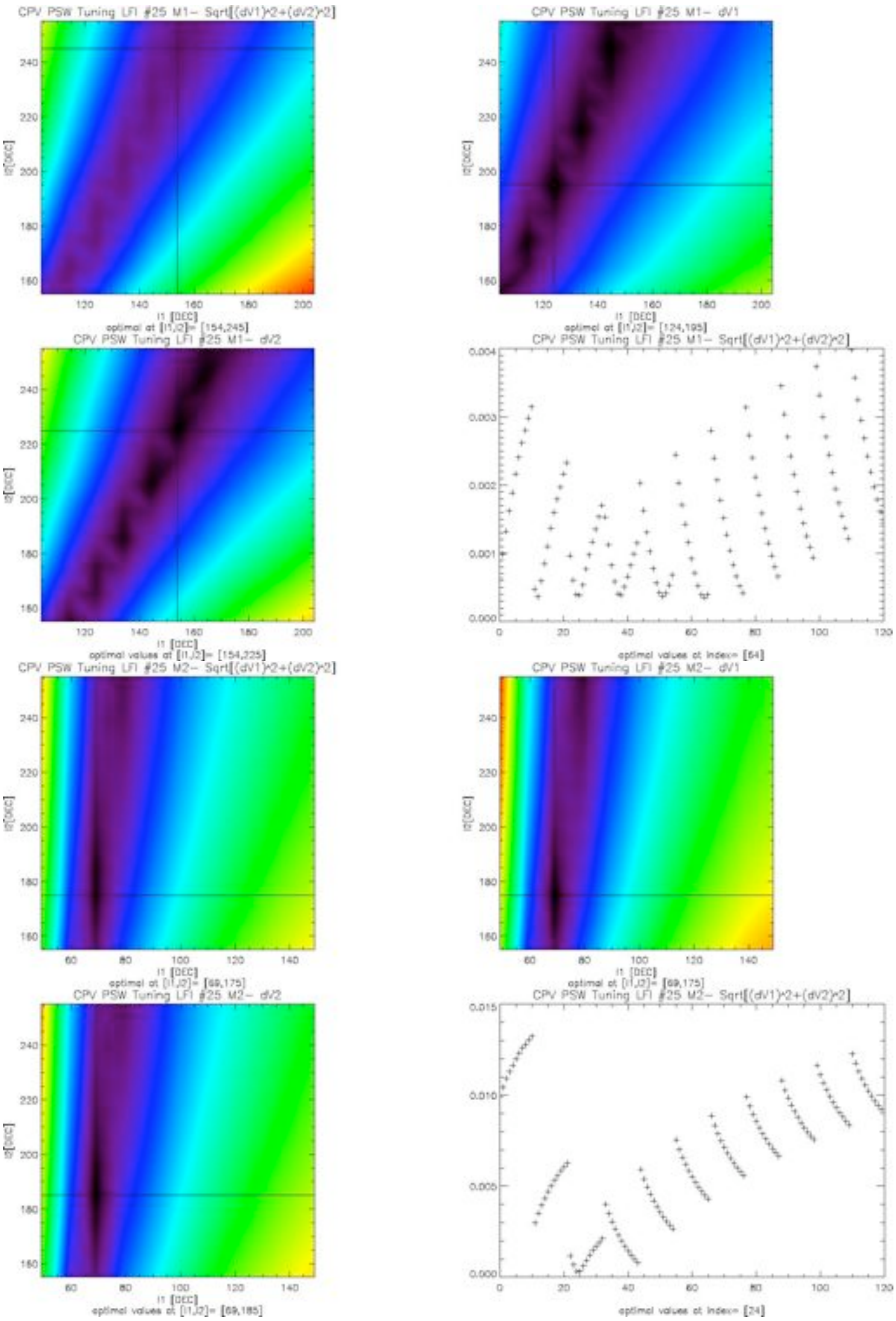
In addition in both files a plot of ΔV is reported to check the regularity of the test and to prevent any problems in selection as occurred during the CSL test analysis.

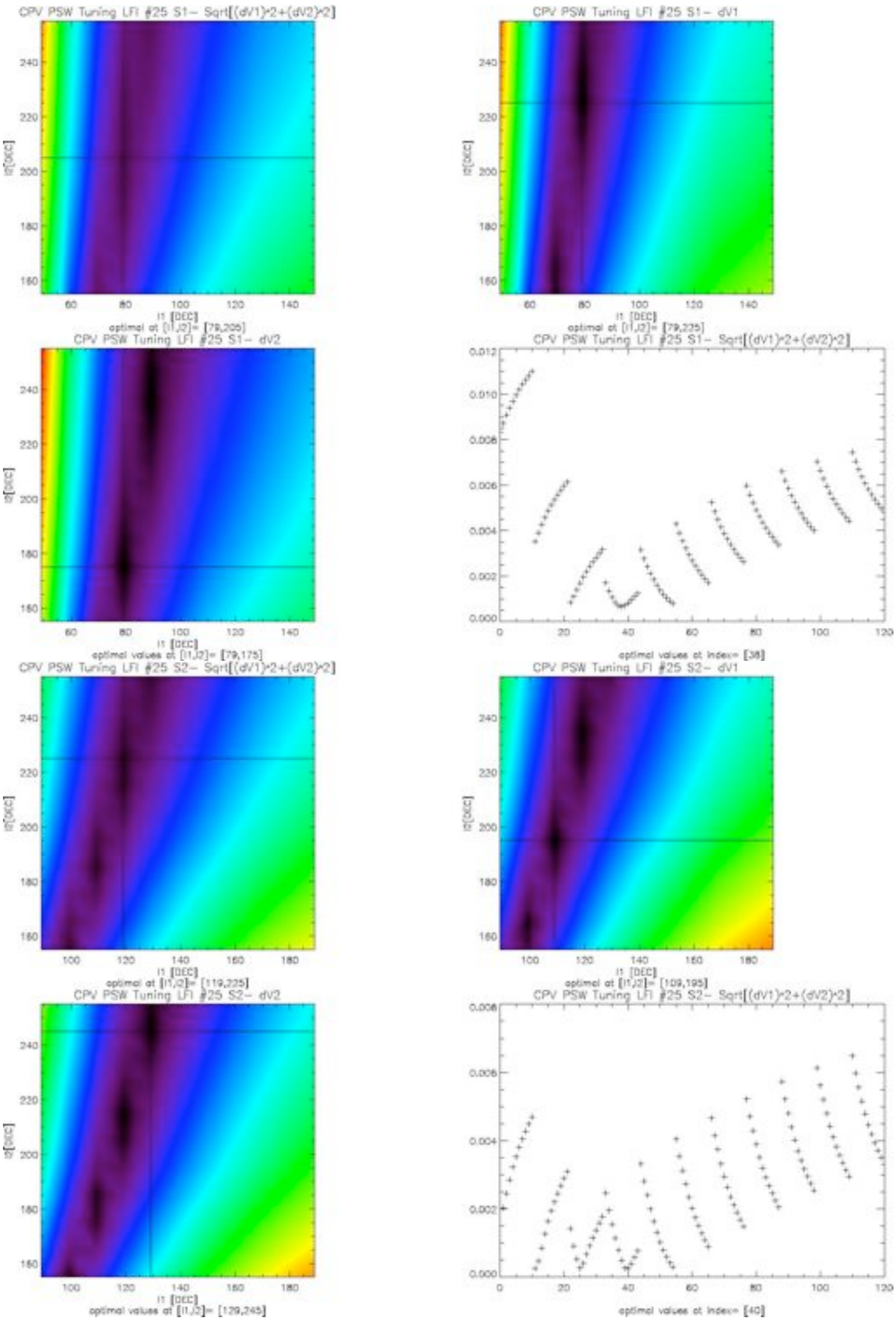
The contour plots are reported in the figures in the following pages. For each plot the local minimum has been found and reported.

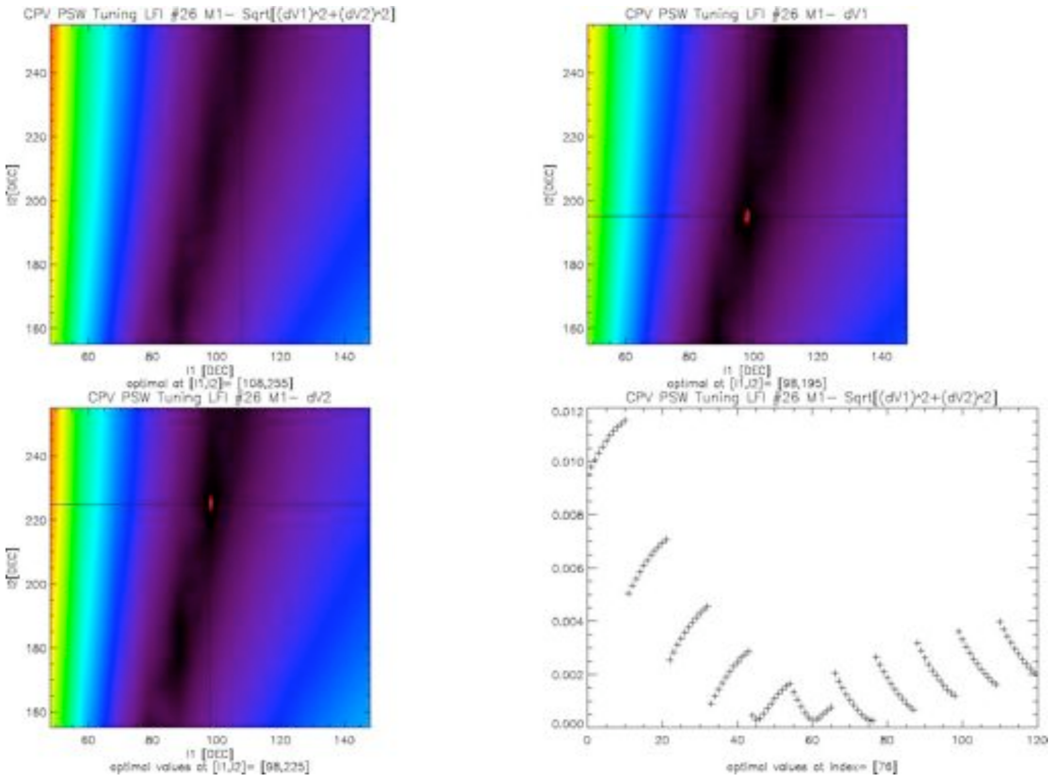

CPV PSW Tuning LFI #24 M1- Sqrt[(dV1)^2+(dV2)^2]
optimal at [I1,I2]= [88,175]
CPV PSW Tuning LFI #24 M1- dV1
optimal at [I1,I2]= [108,255]
CPV PSW Tuning LFI #24 M1- dV2
optimal values at [I1,I2]= [98,225]
CPV PSW Tuning LFI #24 M1- Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [13]
CPV PSW Tuning LFI #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]

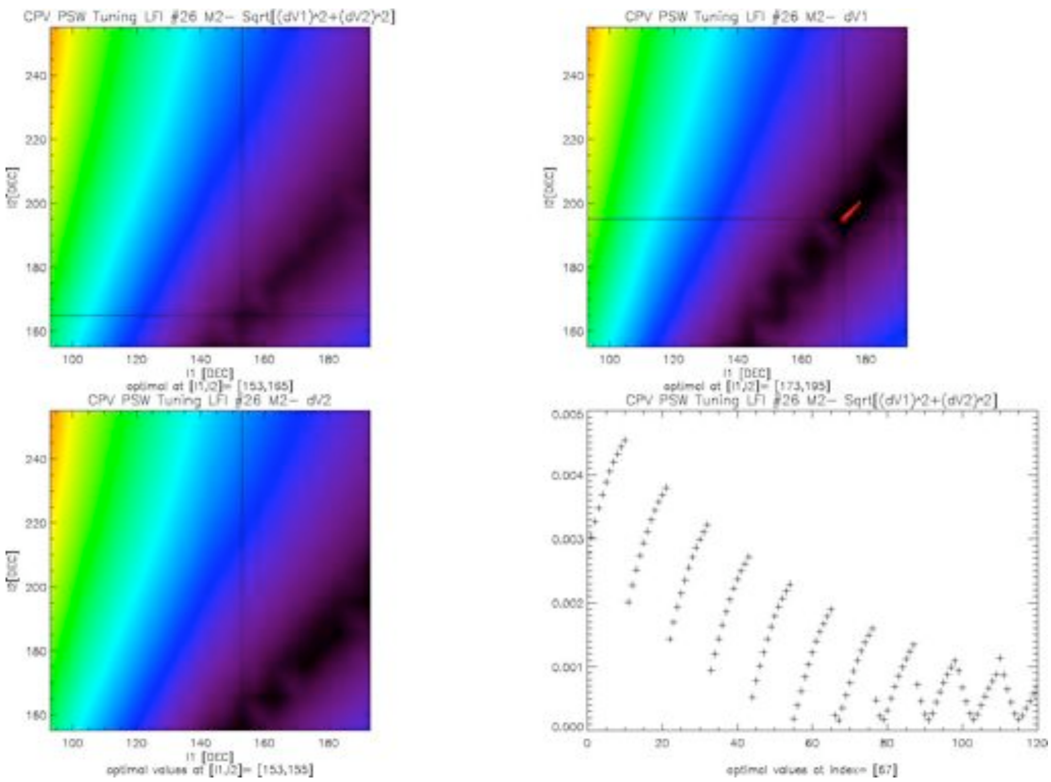

CPV PSW Tuning LFI #24 S1– Sqrt[(dV1)^2+(dV2)^2]
optimal at [I1,I2]= [84,235]
CPV PSW Tuning LFI #24 S1– dV1
optimal at [I1,I2]= [84,225]
CPV PSW Tuning LFI #24 S1– dV2
optimal values at [I1,I2]= [84,235]
CPV PSW Tuning LFI #24 S1– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [41]

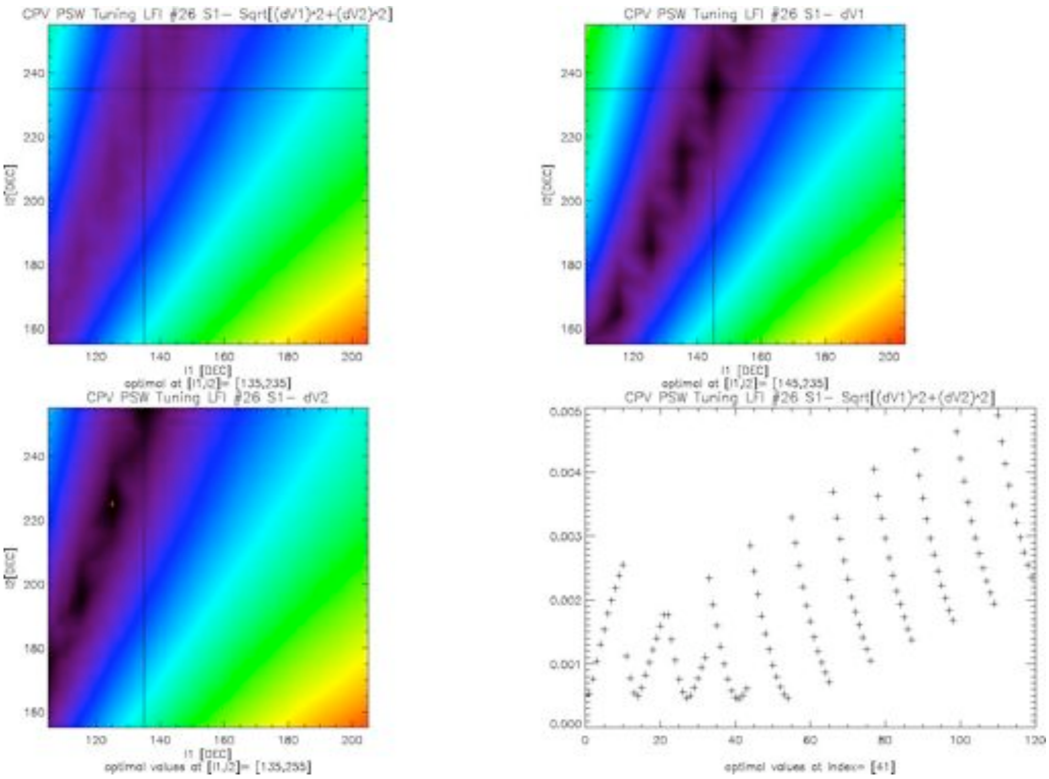

CPV PSW Tuning LFI #24 S2– Sqrt[(dV1)^2+(dV2)^2]
optimal at [I1,I2]= [86,205]
CPV PSW Tuning LFI #24 S2– dV1
optimal at [I1,I2]= [86,195]
CPV PSW Tuning LFI #24 S2– dV2
optimal values at [I1,I2]= [76,165]
CPV PSW Tuning LFI #24 S2– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [36]

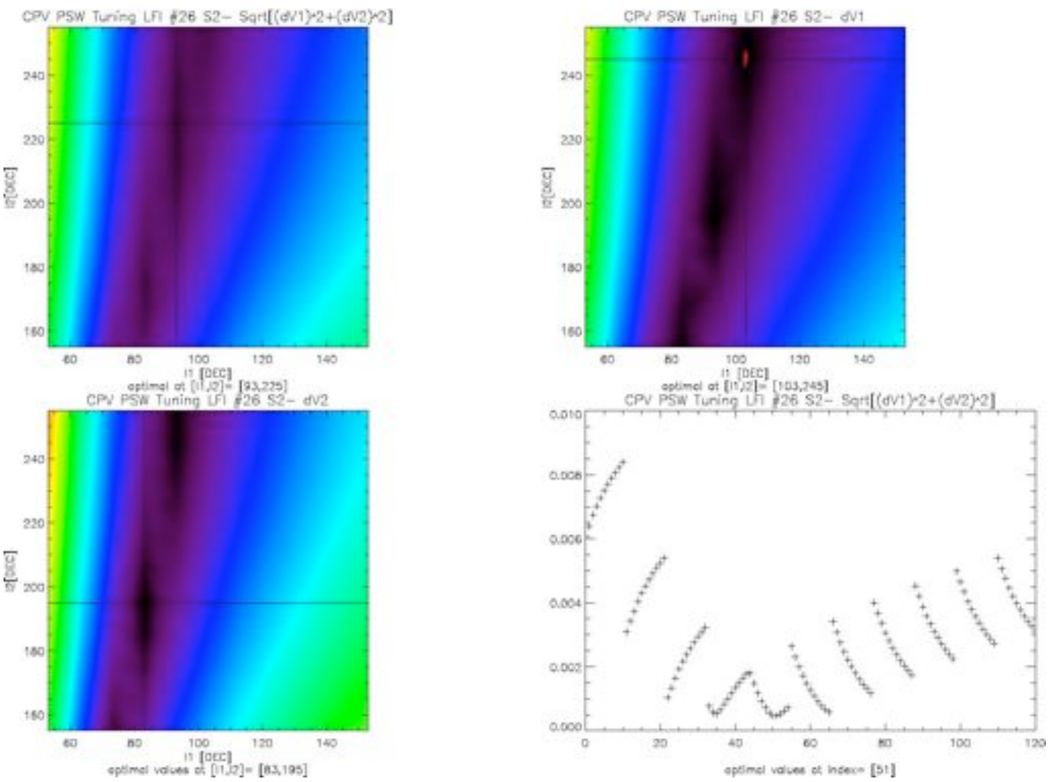

CPV PSW Tuning LFI #25 M1- Sqrt[(dV1)^2+(dV2)^2]
optimal at [i1,i2]= [154,245]
CPV PSW Tuning LFI #25 M1- dV1
optimal at [i1,i2]= [124,195]
CPV PSW Tuning LFI #25 M1- dV2
optimal values at [i1,i2]= [154,225]
CPV PSW Tuning LFI #25 M1- Sqrt[(dV1)^2+(dV2)^2]
optimal values at index= [64]
CPV PSW Tuning 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]

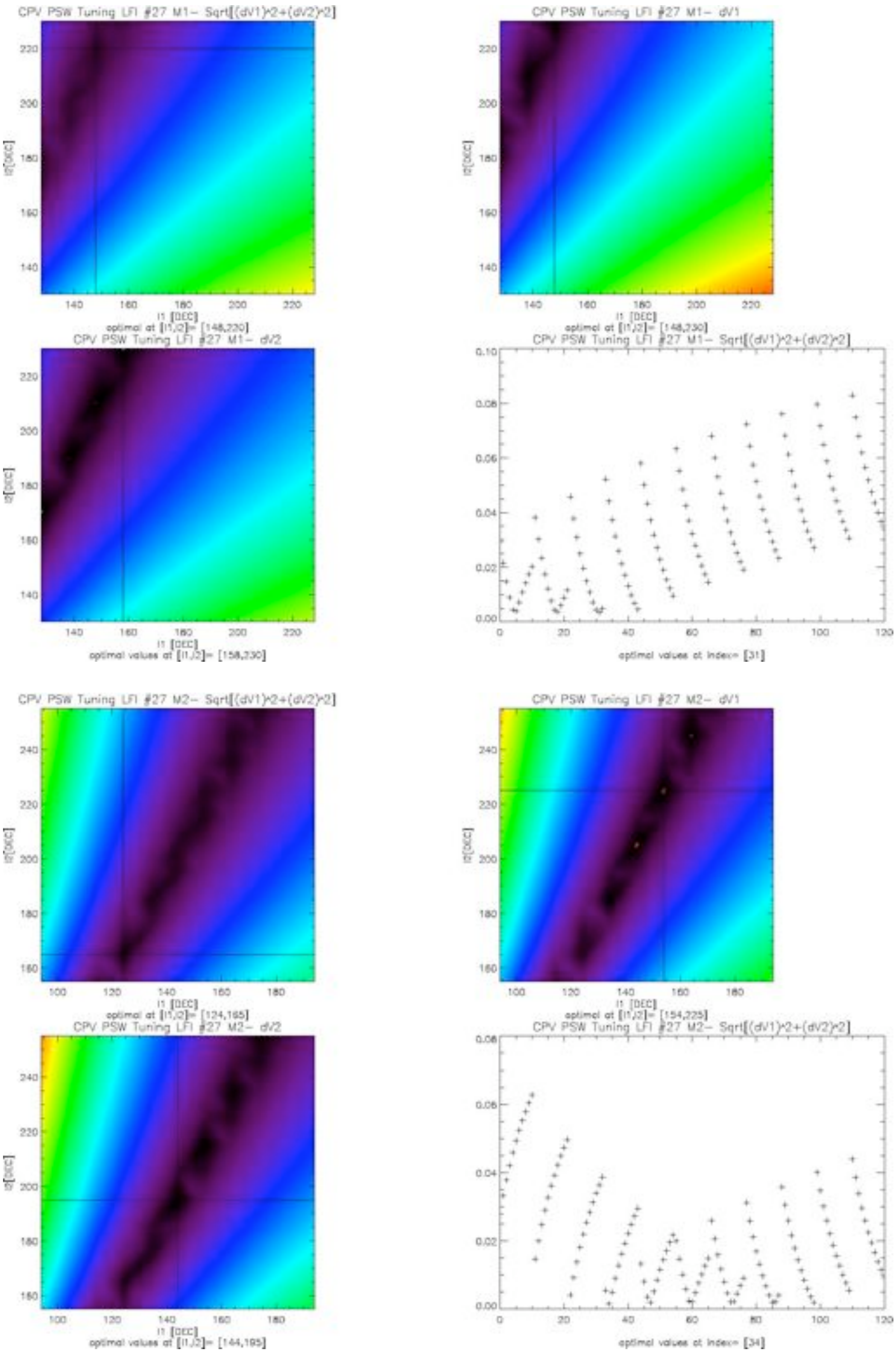

CPV PSW Tuning LFI #25 S1- Sqrt[(dV1)^2+(dV2)^2]
optimal at [I1,I2]= [79,205]
CPV PSW Tuning LFI #25 S1- dV1
optimal at [I1,I2]= [79,225]
CPV PSW Tuning LFI #25 S1- dV2
optimal values at [I1,I2]= [79,175]
CPV PSW Tuning LFI #25 S1- Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [38]
CPV PSW Tuning LFI #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]
I1 [DEC]
I2 [DEC]

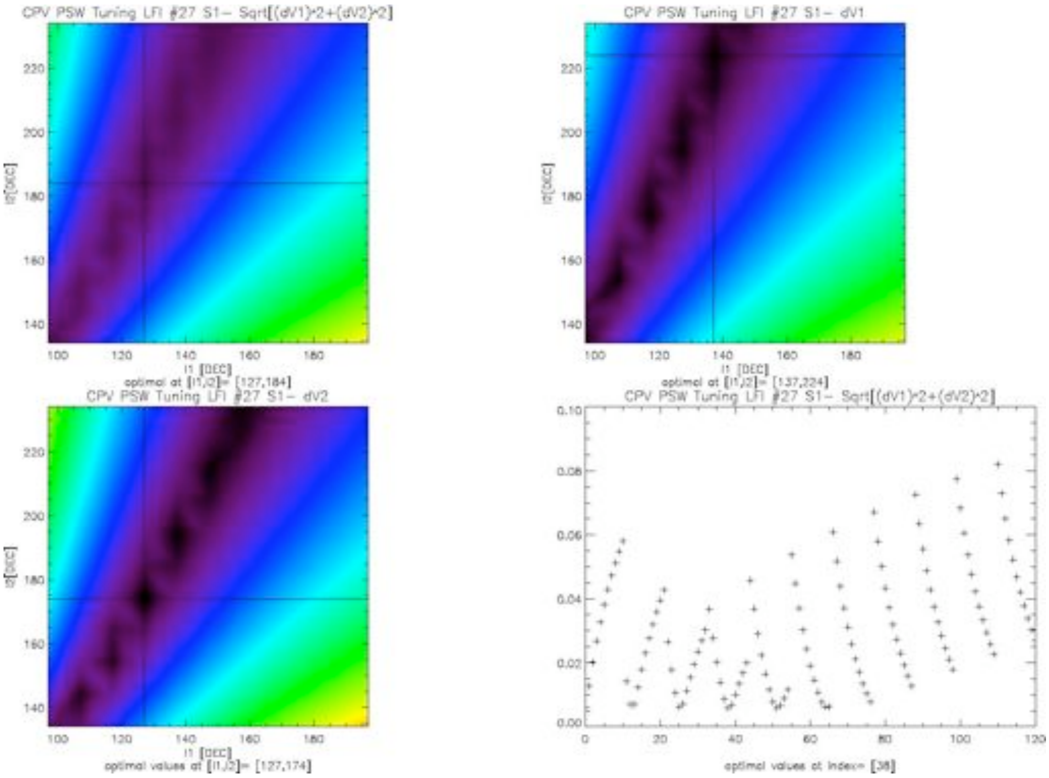

CPV PSW Tuning LFI #26 M1– Sqrt[(dV1)^2+(dV2)^2]
optimal at [I1,I2]= [108,255]
CPV PSW Tuning LFI #26 M1– dV1
optimal at [I1,I2]= [98,195]
CPV PSW Tuning LFI #26 M1– dV2
optimal values at [I1,I2]= [98,225]
CPV PSW Tuning LFI #26 M1– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [76]


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

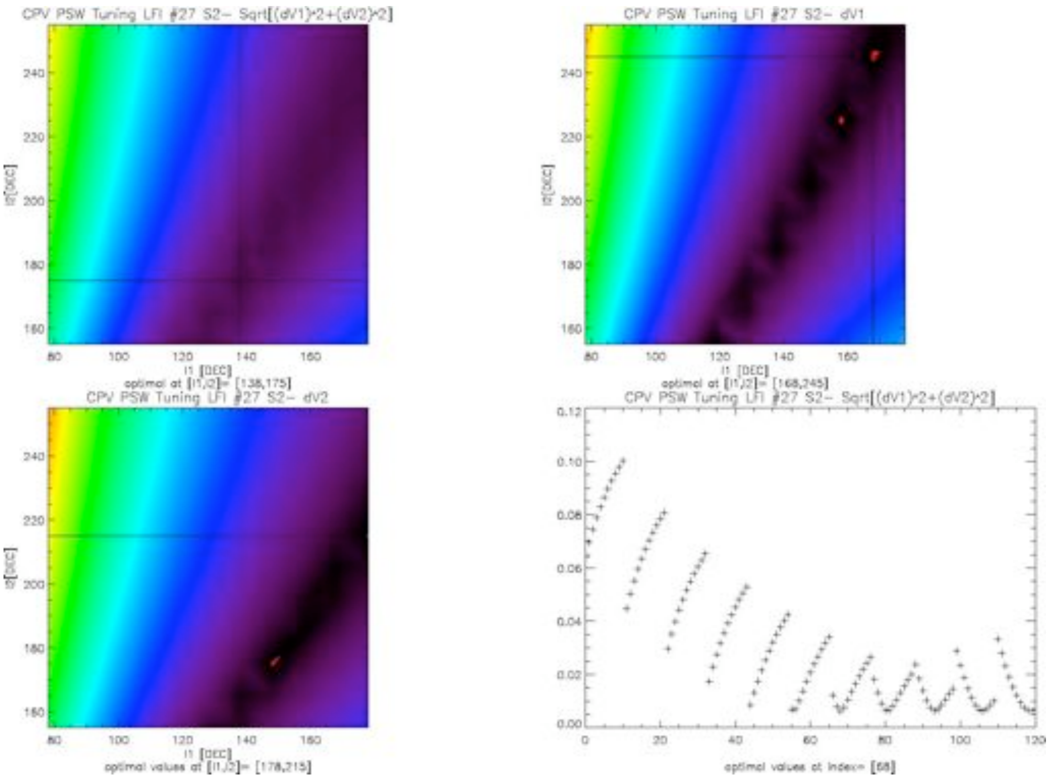

CPV PSW Tuning LFI #26 S1– Sqrt[(dV1)^2+(dV2)^2]
optimal at [I1,I2]= [135,235]
CPV PSW Tuning LFI #26 S1– dV1
optimal at [I1,I2]= [145,235]
CPV PSW Tuning LFI #26 S1– dV2
optimal values at [I1,I2]= [135,235]
CPV PSW Tuning LFI #26 S1– Sqrt[(dV1)^2+(dV2)^2]
optimal values at index= [41]
I1 [DEC]
I2[DEC]


CPV PSW Tuning LFI #26 S2– Sqrt[(dV1)^2+(dV2)^2]
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]
I1 [DEC]
I2[DEC]

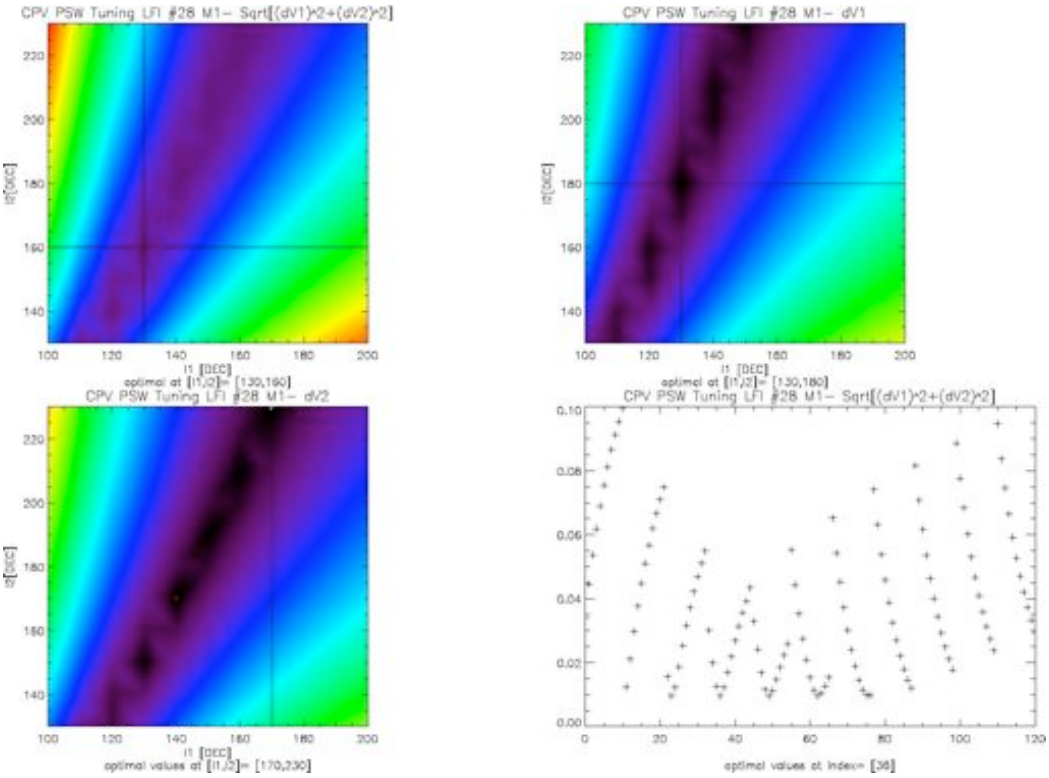

CPV PSW Tuning LFI #27 M1- Sqrt[(dV1)^2+(dV2)^2]
optimal at [I1,I2]= [148,220]
CPV PSW Tuning LFI #27 M1- dV1
optimal at [I1,I2]= [148,230]
CPV PSW Tuning LFI #27 M1- dV2
optimal values at [I1,I2]= [158,230]
CPV PSW Tuning LFI #27 M1- Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [31]
CPV PSW Tuning LFI #27 M2- Sqrt[(dV1)^2+(dV2)^2]
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]
I1 [DEC]
I2 [DEC]

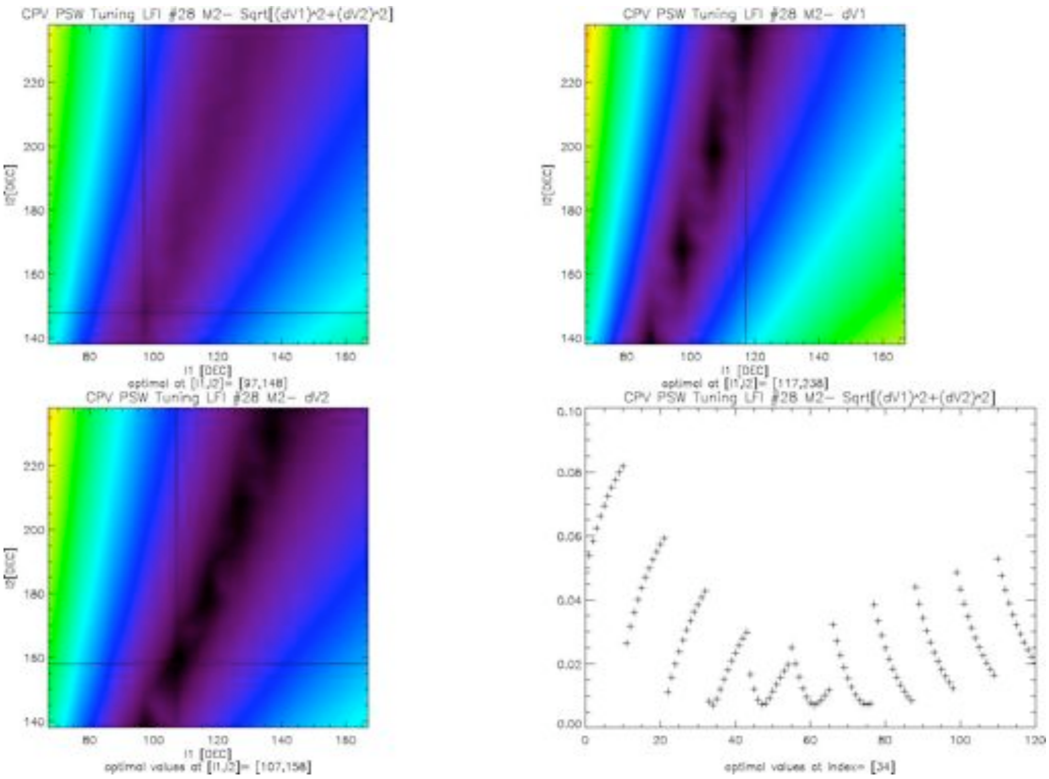


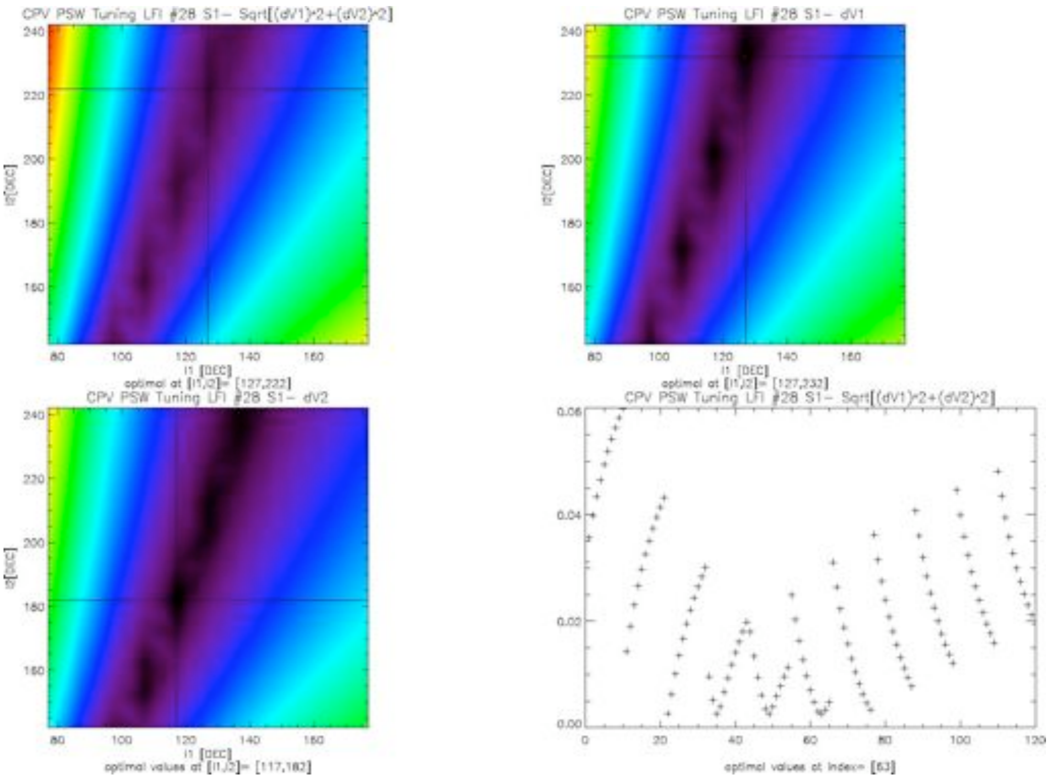
CPV PSW Tuning LFI #27 S1- Sqrt[(dV1)^2+(dV2)^2]
optimal at [I1,I2]= [127,184]
CPV PSW Tuning LFI #27 S1- dV1
optimal at [I1,I2]= [137,224]
CPV PSW Tuning LFI #27 S1- dV2
optimal values at [I1,I2]= [127,174]
CPV PSW Tuning LFI #27 S1- Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [38]

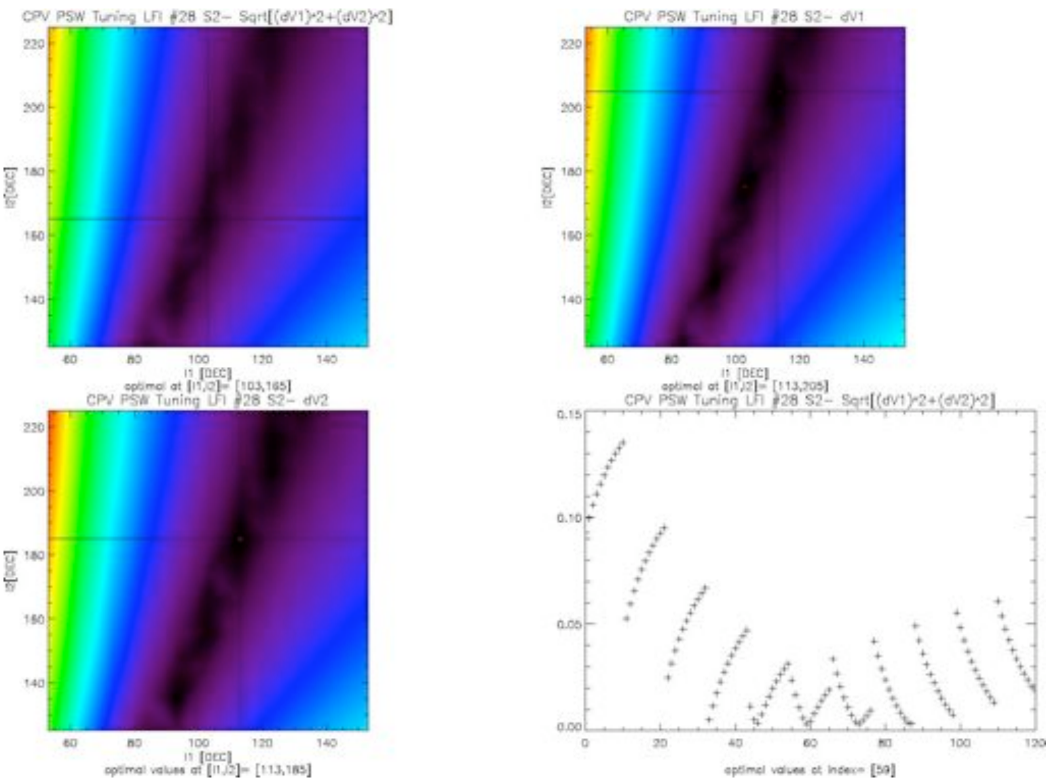


CPV PSW Tuning LFI #27 S2- Sqrt[(dV1)^2+(dV2)^2]
optimal at [I1,I2]= [138,175]
CPV PSW Tuning LFI #27 S2- dV1
optimal at [I1,I2]= [168,245]
CPV PSW Tuning LFI #27 S2- dV2
optimal values at [I1,I2]= [178,215]
CPV PSW Tuning LFI #27 S2- Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [68]


CPV PSW Tuning LFI #28 M1- Sqrt[(dV1)^2+(dV2)^2]
I1 [DEC]
I2[DEC]
optimal at [I1,I2]= [130,160]
CPV PSW Tuning LFI #28 M1- dV1
optimal at [I1,I2]= [130,180]
CPV PSW Tuning LFI #28 M1- dV2
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]
I1 [DEC]
I2[DEC]
optimal at [I1,I2]= [97,148]
CPV PSW Tuning LFI #28 M2- dV1
optimal at [I1,I2]= [117,238]
CPV PSW Tuning LFI #28 M2- dV2
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]
optimal at [I1,I2]= [127,222]
CPV PSW Tuning LFI #28 S1– dV1
optimal at [I1,I2]= [127,232]
CPV PSW Tuning LFI #28 S1– dV2
optimal values at [I1,I2]= [117,182]
CPV PSW Tuning LFI #28 S1– Sqrt[(dV1)^2+(dV2)^2]
optimal values at Index= [63]
I1 [DEC]
I2[DEC]


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

5.2 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 ΔV 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.

5.3 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.

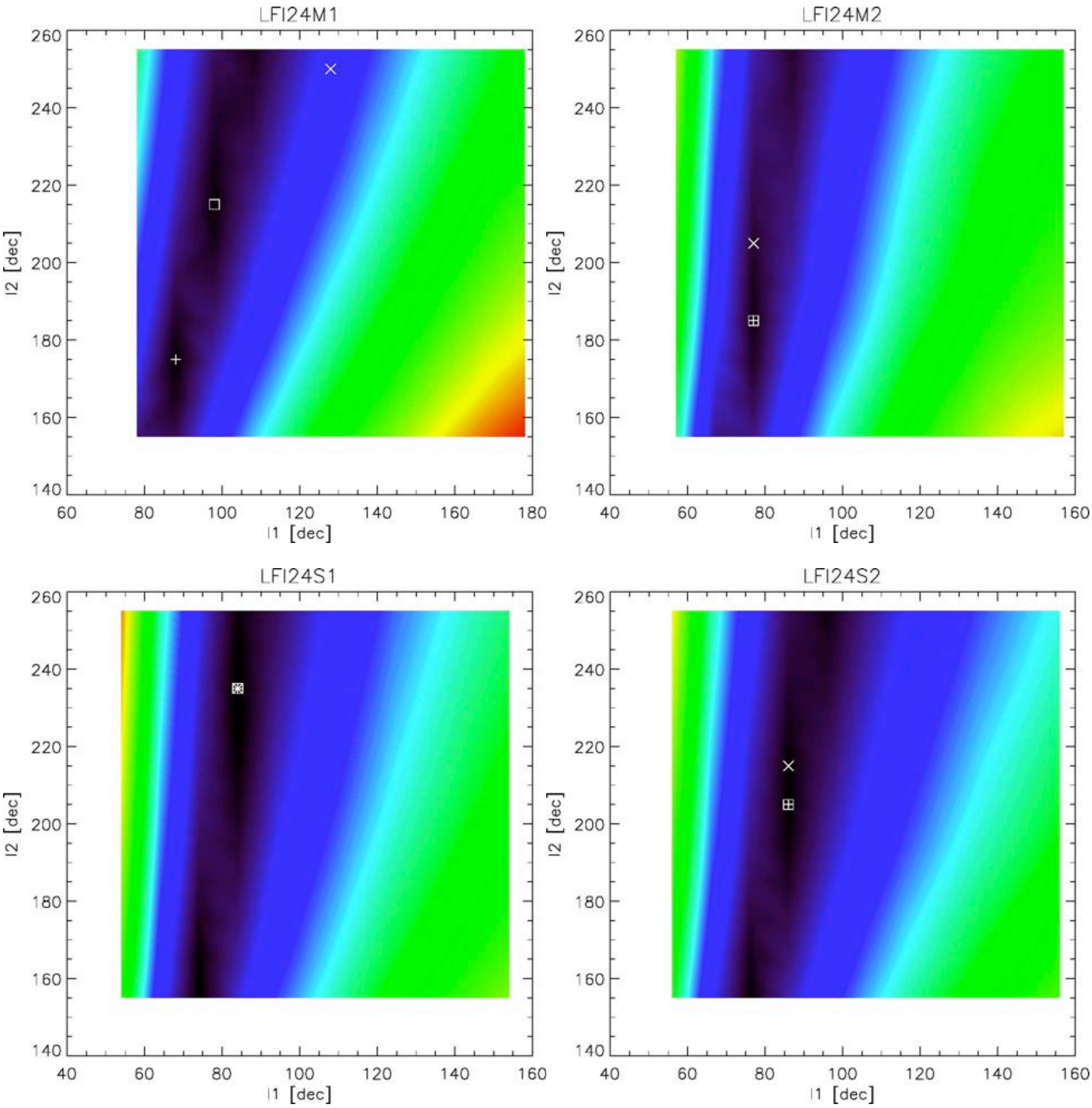


Figure 11: RCA24 Phase switch results comparison. The coloured contour plot area is the data derived from CPV phase switch tuning test. Cross sign is the optimal point found during CSL test. Plus sign is the optimal point found during CPV test. The square point is the final optimal point chosen.

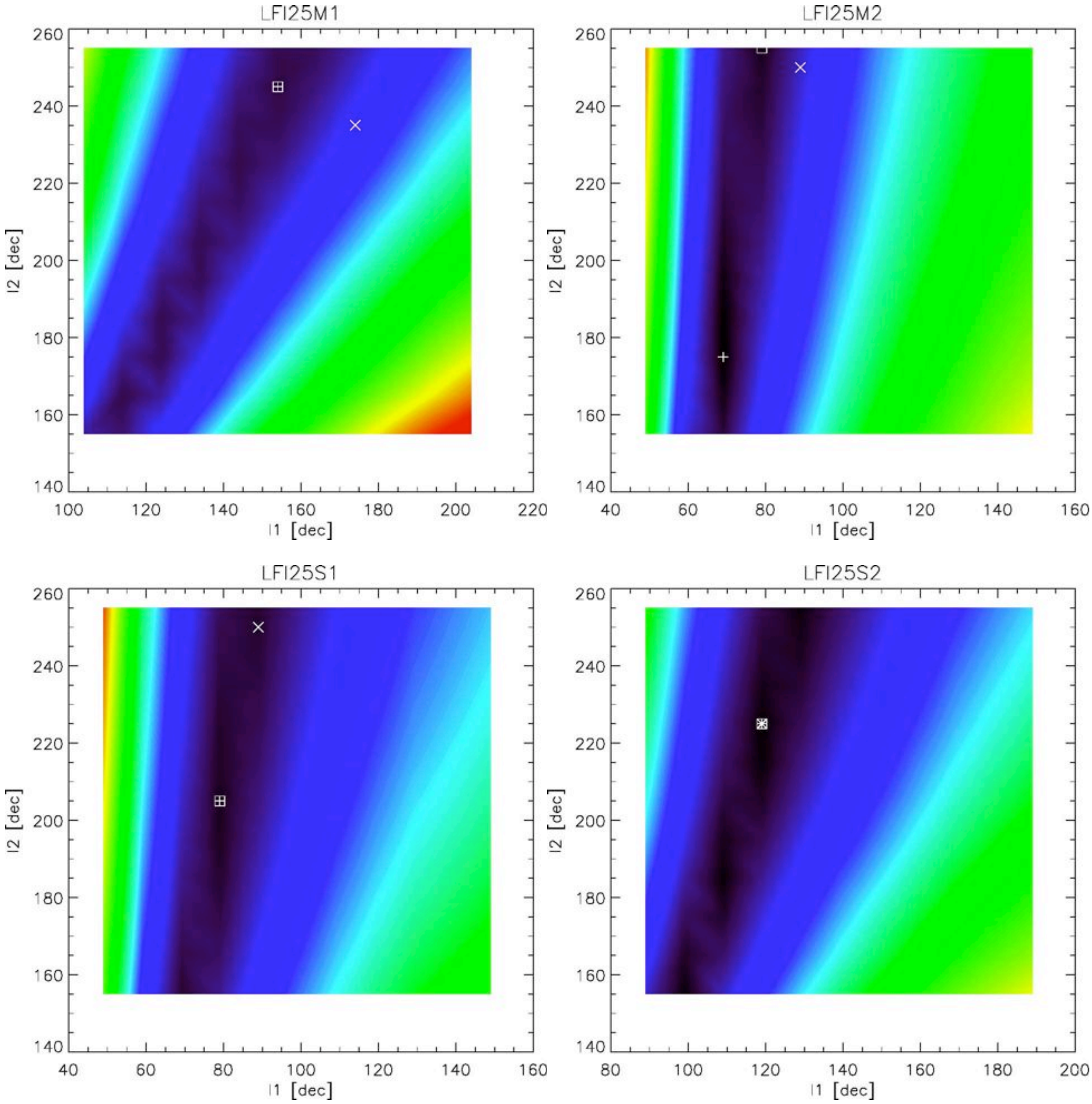


Figure 12: RCA25 Phase switch results comparison. The coloured contour plot area is the data derived from CPV phase switch tuning test. Cross sign is the optimal point found during CSL test. Plus sign is the optimal point found during CPV test. The square point is the final optimal point chosen.

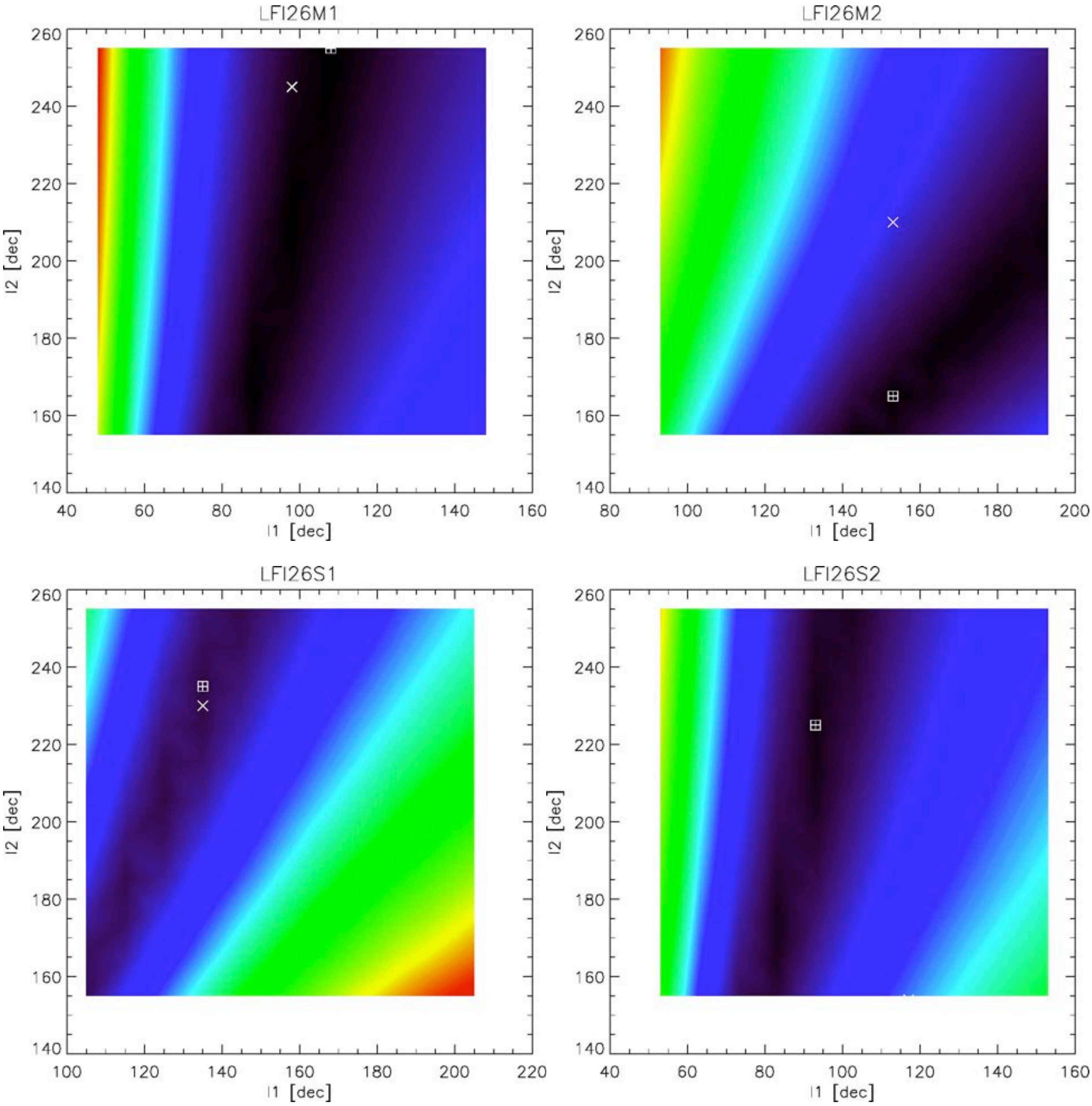


Figure 13: RCA26 Phase switch results comparison. The coloured contour plot area is the data derived from CPV phase switch tuning test. Cross sign is the optimal point found during CSL test. Plus sign is the optimal point found during CPV test. The square point is the final optimal point chosen.

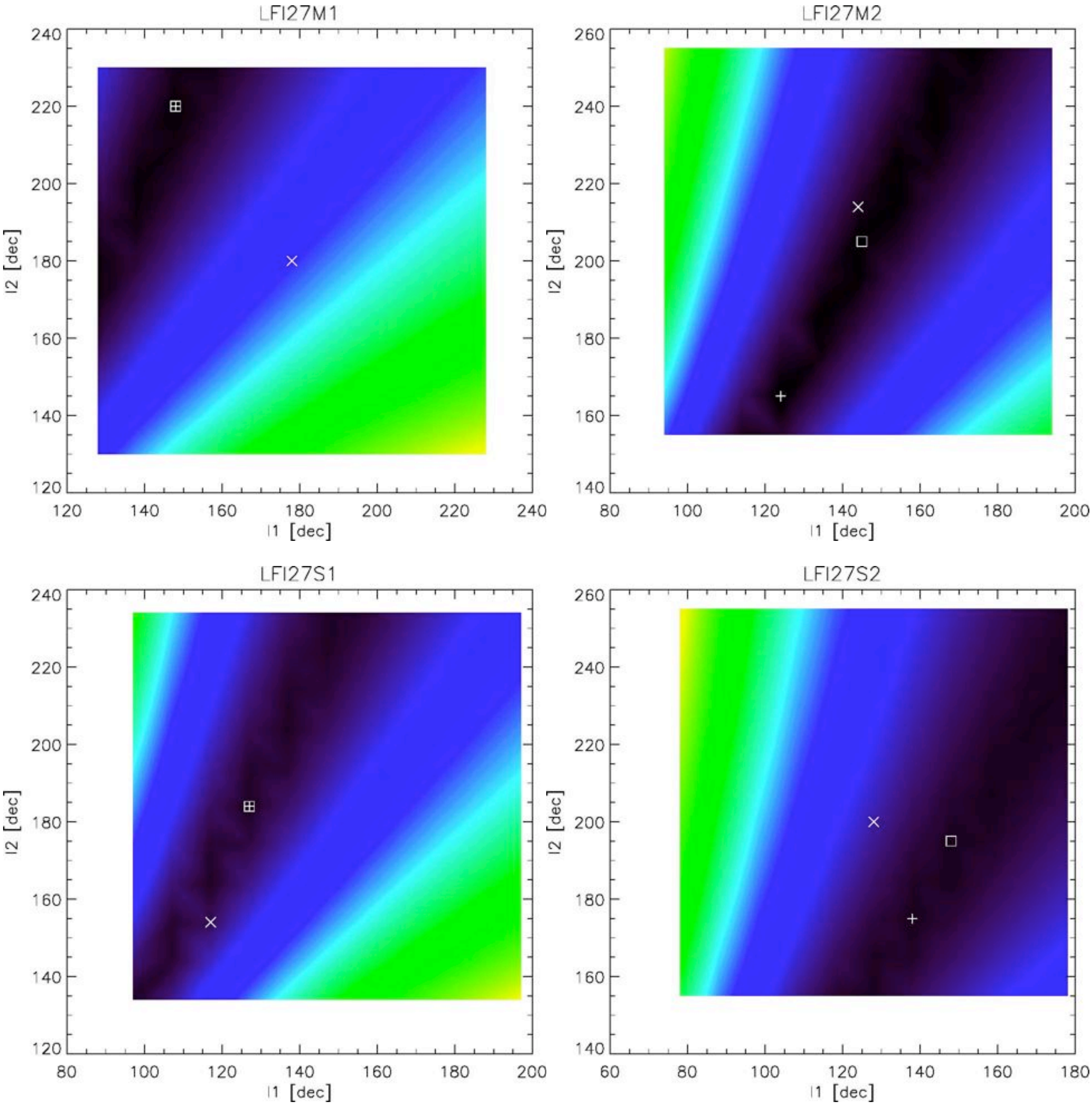


Figure 14: RCA27 Phase switch results comparison. The coloured contour plot area is the data derived from CPV phase switch tuning test. Cross sign is the optimal point found during CSL test. Plus sign is the optimal point found during CPV test. The square point is the final optimal point chosen.

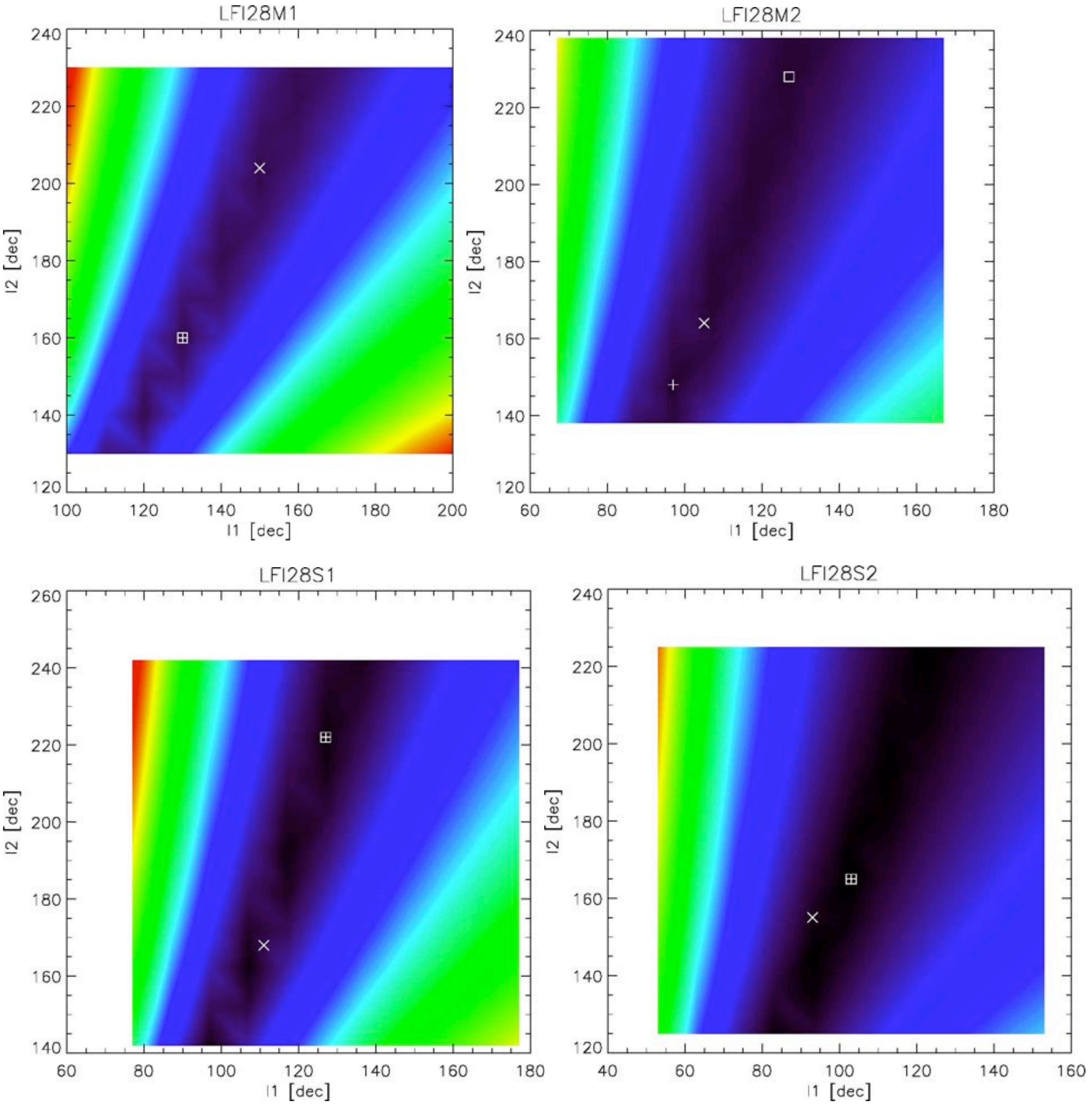


Figure 15: RCA28 Phase switch results comparison. The coloured contour plot area is the data derived from CPV phase switch tuning test. Cross sign is the optimal point found during CSL test. Plus sign is the optimal point found during CPV test. The square point is the final optimal point chosen.

6 PSW Tuning: 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.

7 PSW Verification: Test Execution

7.1 Test configuration

The test configuration is the following

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

LFI Personnel involved during the test is:

LFI Instrument Operation Manager	Anna Gregorio (UniTs anna.gregorio@ts.infn.it)
LFI Calibration Scientist	Aniello Mennella (UniMi aniello.mennella@fisica.unimi.it)
LFI CPV Manager	Francesco Cuttaia (IASF-BO cuttaia@iasfbo.inaf.it)
Test leader	Fabrizio Villa (IASF-BO villa@iasfbo.inaf.it)
LFI IOT	Anna Gregorio, Francesco Cuttaia, Aniello Mennella, Marco Frailis, Samuele Galeotta, Andrea Zacchei, Maurizio Tomasi, Althea Wilkinson, Peter Meinhold, Richard Davis, Daniele Tavagnacco
Industry support	Paola Battaglia

7.2 Pass-fail criteria, verification matrix

CPV	**P_PVP_LFI_0104_01**				
July, 15th 2009	**DoY 195**	**OD 63**			
Duration	**9:59:46**				
Test name:	**P/S tuning verification**				
Test objectives:	The main objective of the test is to verify the balance of the two diodes in each PS of each FEM unit once ACA biased are tuned. 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 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	Yes				
TC procedure	Yes				
Every P/S is responding to bias stimuli as expected	Yes				
Correct biases for P/S balancing Applied and Checked	Yes				
No unexpected features		no	The test was performed using the new bias values resulting from previous HYM tuning tests. During the test, performed outsides visibility, each arm of every RCA is switched off and back on. While applying RCA 24 soft switch on procedure (tested on ground and in flight on CSL biases), RCA 24 S1 went in an oscillation mode that created saturation effects on RCA 27 (resident in the same power group). The effect was exactly the same already seen in CSL that indeed was cured by using the ad-hoc soft switch on procedure. Since this is a verification test and the results on the other RCAs confirmed the validity of previous values, it has been agreed the test does not need to be redone.	yes	
Data saved and stored at DPC	Yes				

7.3 Procedure/ Test sequence and environmental conditions

See chapter 4.3.

The test started at 2009-06-17T21:30:00 UTC and ended at 2009-06-18T07:29:46 UTC (OD63). 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.

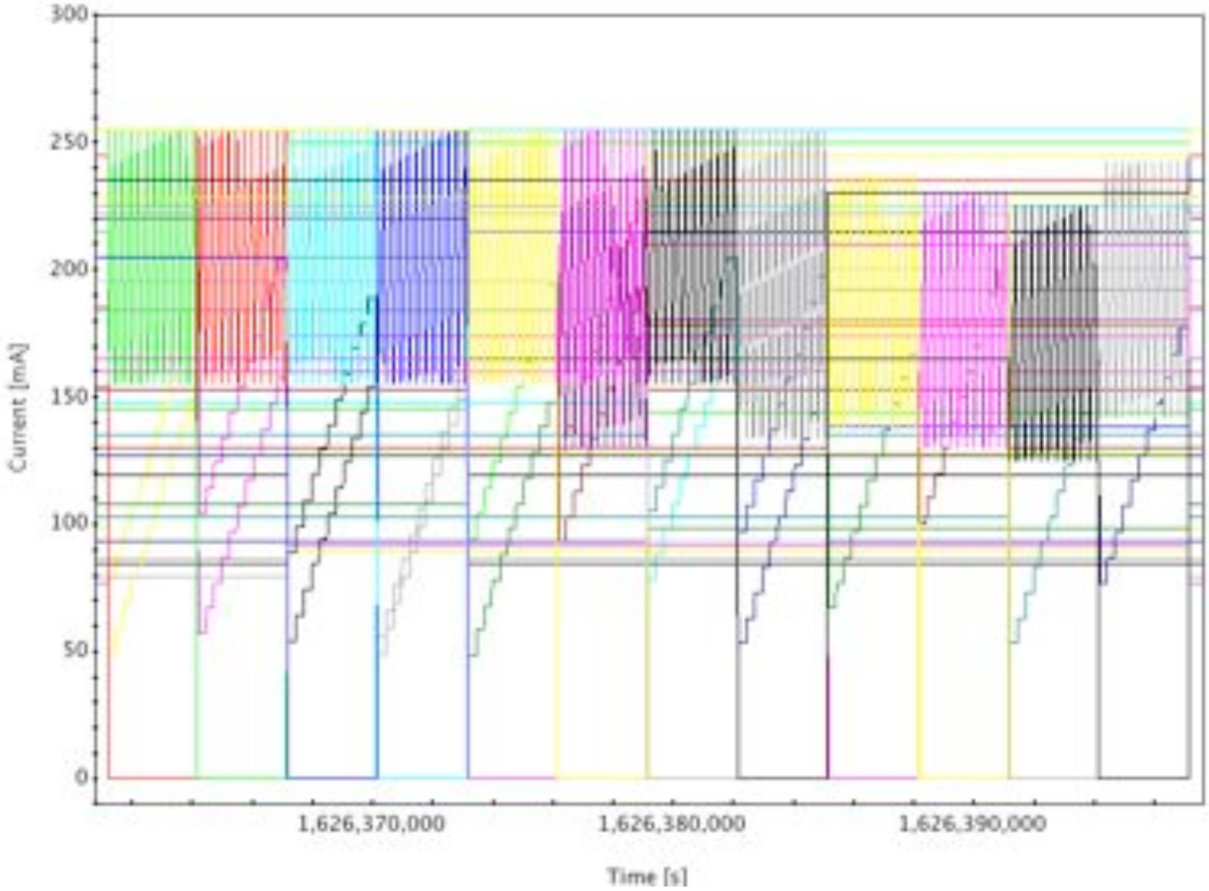


Figure 16. I1 and I2 current values as plotted in pegaso_view

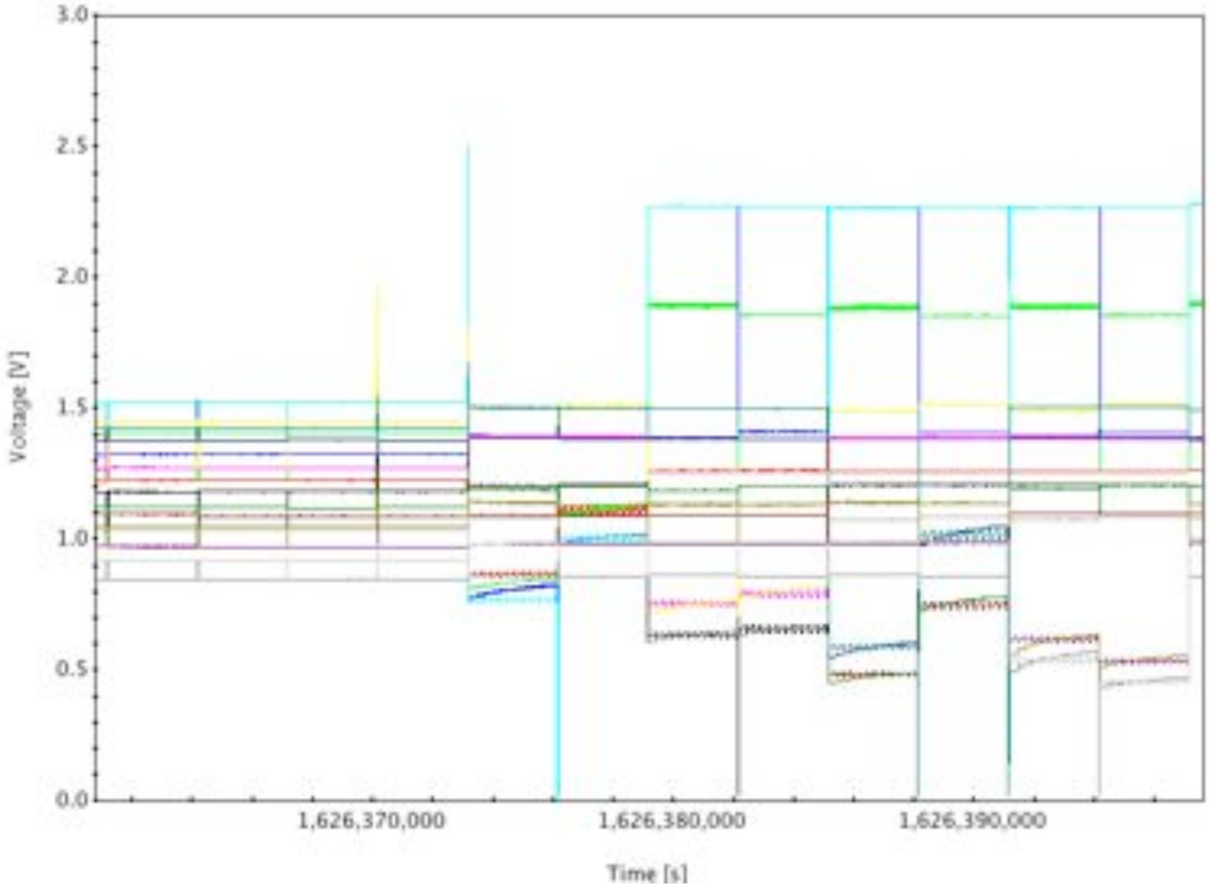


Figure 17. Output radiometer voltages as plotted in pegaso_view for the 30 GHz RCA phase switches tuning

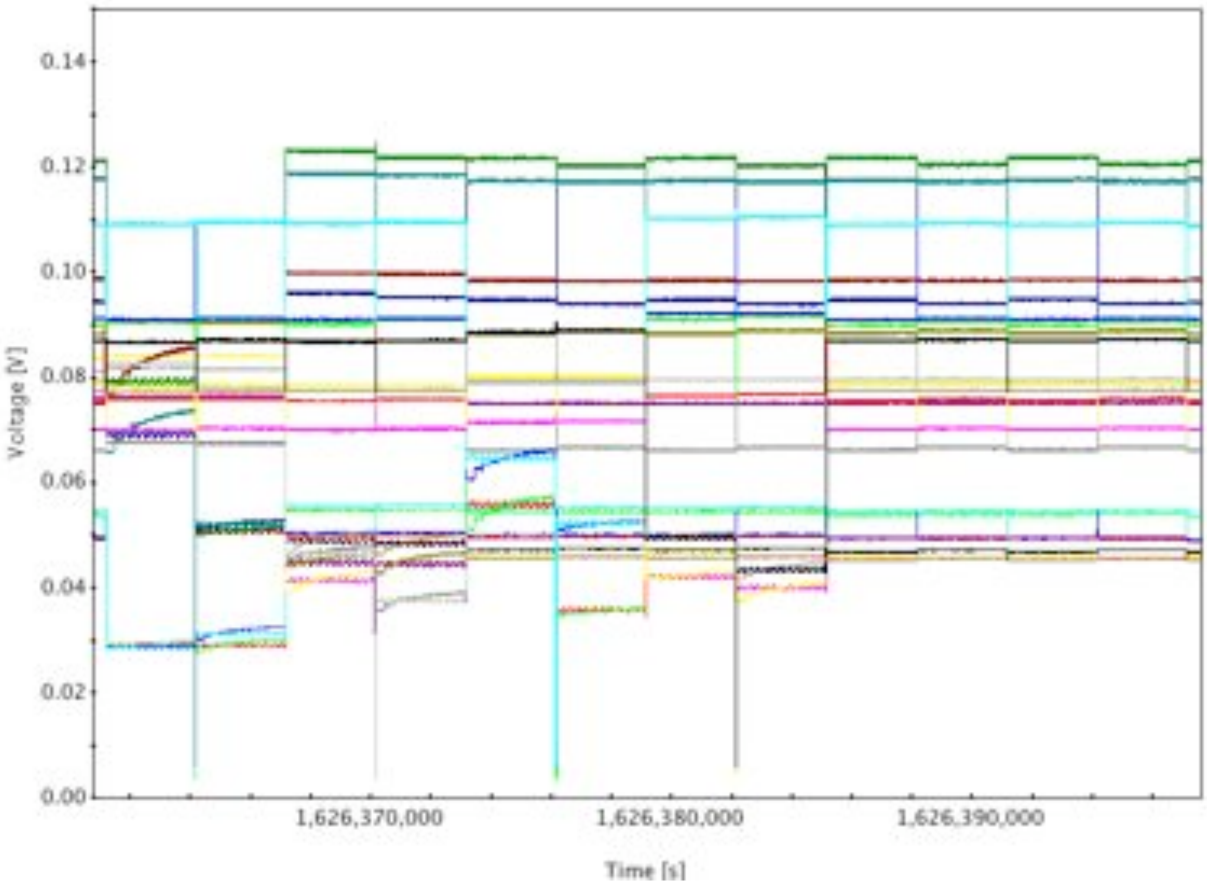


Figure 18. Output radiometer voltages as plotted in pegaso_view for the 30 GHz RCA phase switches tuning

8 PSW Verification: Data analysis

The data analysis was performed in LIFE environment with the following IDL script, namely `cpv_psw_script.pro`. It uses `pegaso_tune_phase_switch_currents()` pegaso routine version 1.9.
The analysis proceeded in one single step by executing 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
ΔV_1 defined as $\Delta V_1 = V_1^{(even)} - V_1^{(odd)}$
$V_1^{(even)}$: 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
ΔV_2 : defined as $\Delta V_2 = V_2^{(even)} - V_2^{(odd)}$
ΔV : defined as $\Delta V = \sqrt{(\Delta V_1)^2 + (\Delta V_2)^2}$

For each phase the following data files were created:

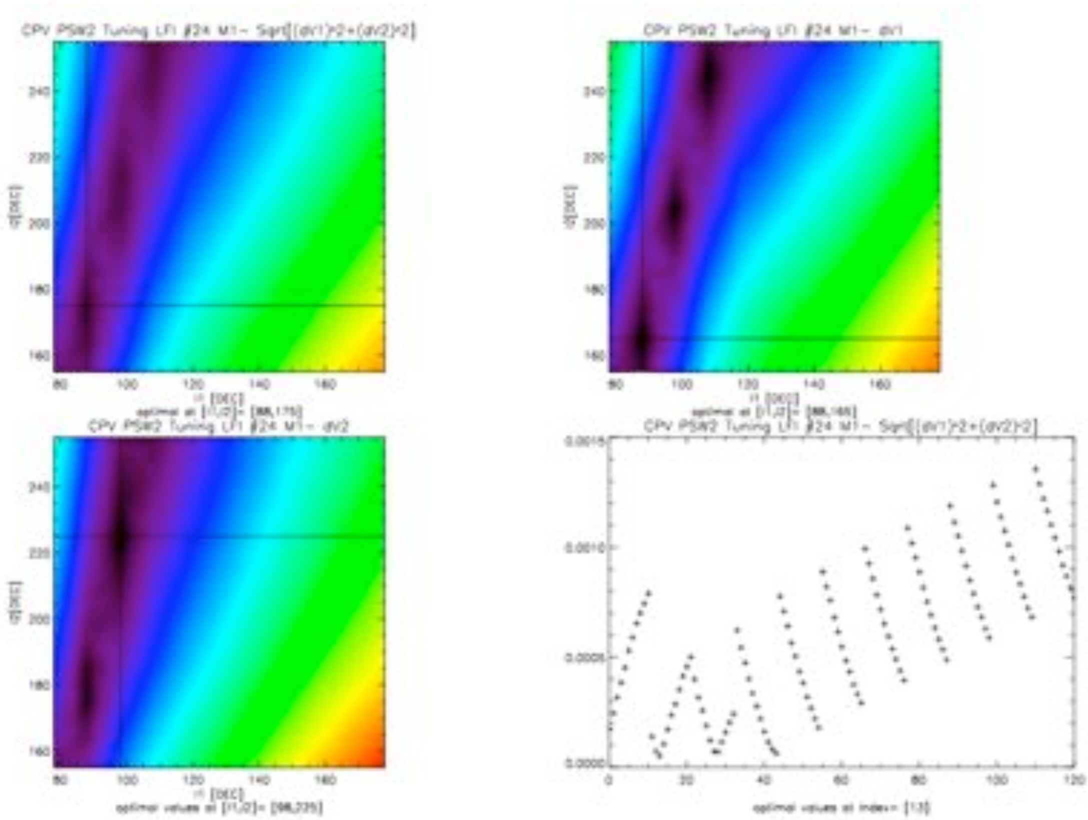
`CPV_PSW2_tuning_raw_LFIXX_ID.csv`
(for example: `CPV_PSW2_tuning_raw_LFI24_M1.csv`)
This file contains all the current changes within the selected time window. This means that also the changes in currents applied during the switching on/off of the ACAs are recorded in this file. The columns reports 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.

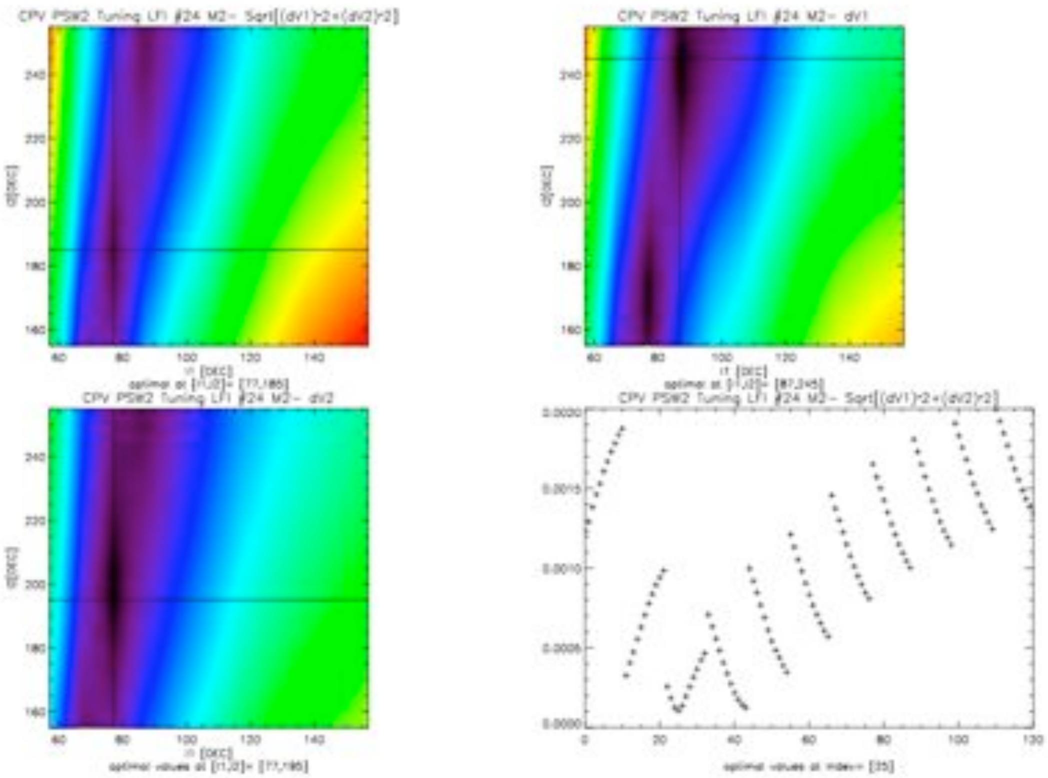
`CPV_PSW2_tuning_LFIXX_ID.csv`
(for example `CPV_PSW_tuning_LFI24_M1.csv`)
this file contains the same information of the above file but for 121 points (11x11) for each phase switch as required by the procedure. The time information has not recorded in this file since it was created mainly for plotting the results. The graphical output is stored in the following files:

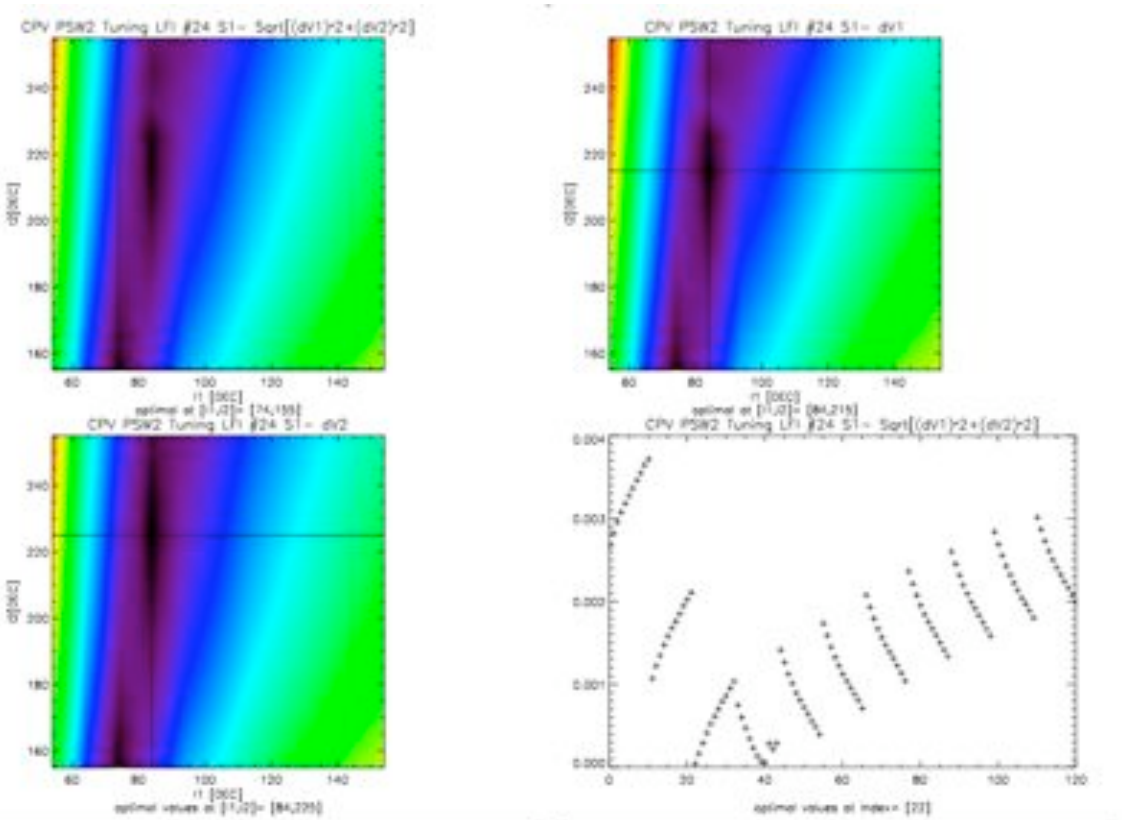
`CPV_PSW2_tuning_LFI24_M1.ps`
containing the contour plot graphical output of ΔV, ΔV_1, and ΔV_2.

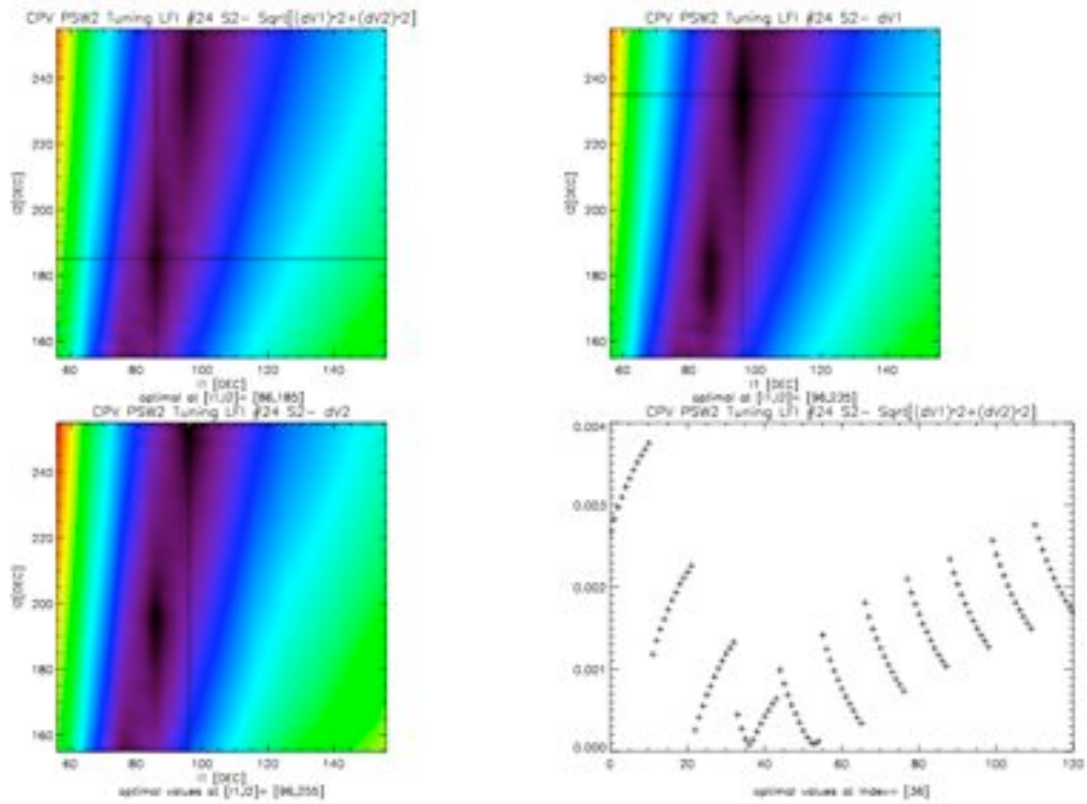
`CPV_PSW2_tuning_LFI24_M1_surf.ps`
containing the surface plot graphical output of ΔV, ΔV_1, and ΔV_2.
In addition in both files a plot of ΔV is reported to check the regularity of the test and to prevent any problems in selection as occurred during the CSL test analysis.

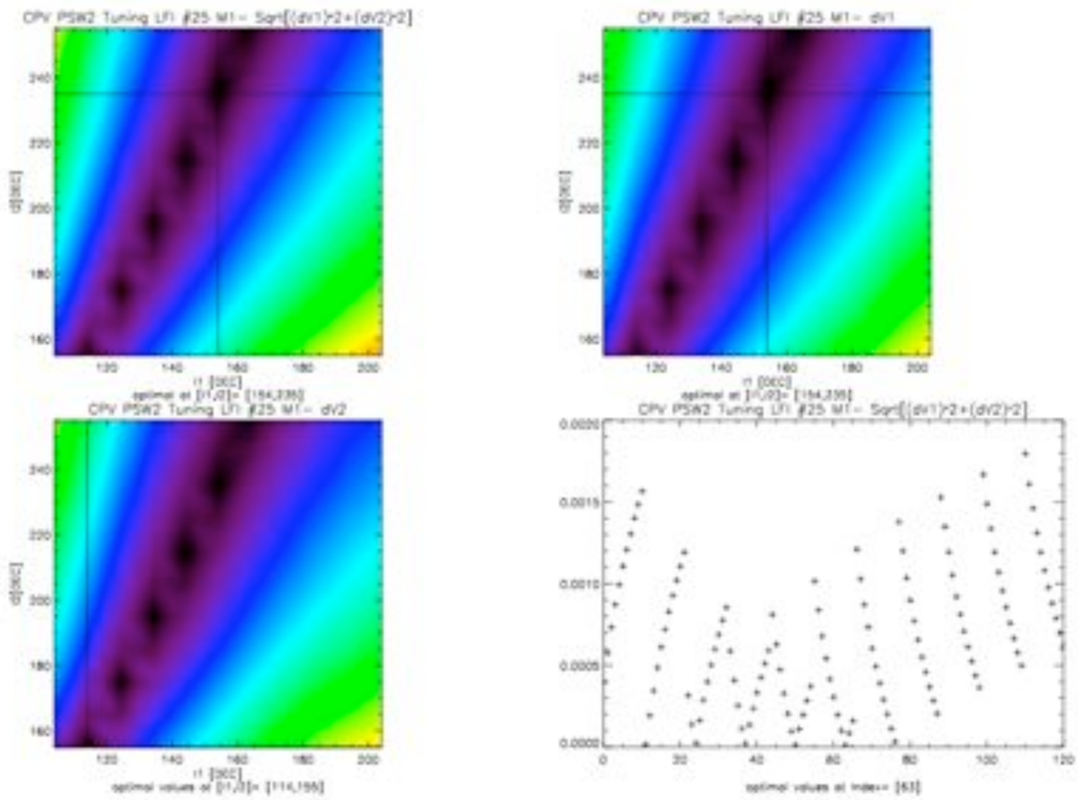
The contour plots are reported in the figures in the following pages. For each plot the local minimum has been found and reported.

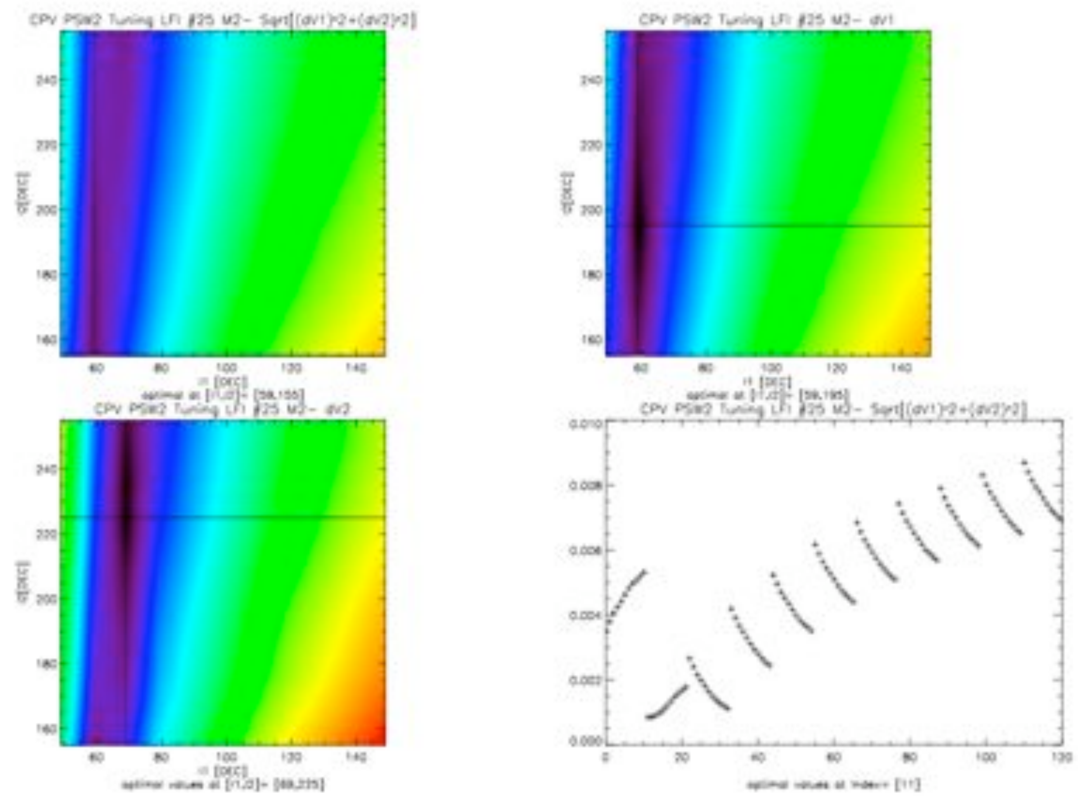

CPV PSW2 Tuning LFI #24 M1- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #24 M1- dV1
CPV PSW2 Tuning LFI #24 M1- dV2
CPV PSW2 Tuning LFI #24 M1- Sqrt[(dV1)^2+(dV2)^2]

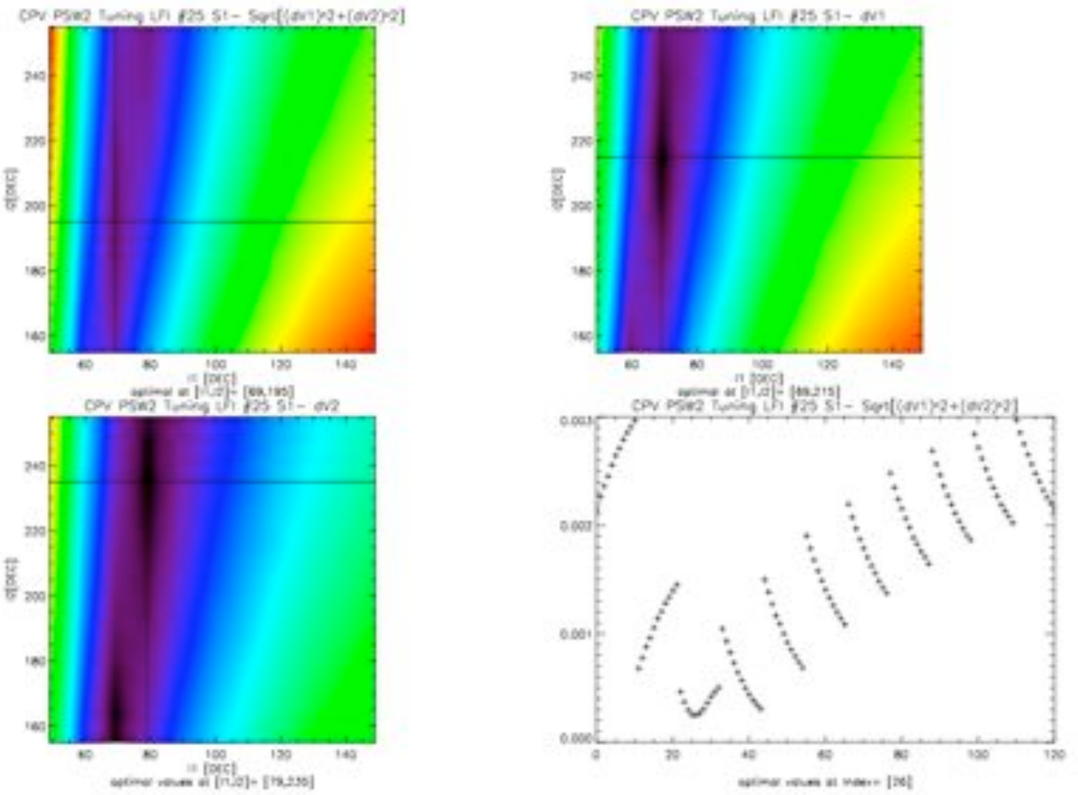

CPV PSW2 Tuning LFI #24 M2- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #24 M2- dV1
CPV PSW2 Tuning LFI #24 M2- dV2
CPV PSW2 Tuning LFI #24 M2- Sqrt[(dV1)^2+(dV2)^2]

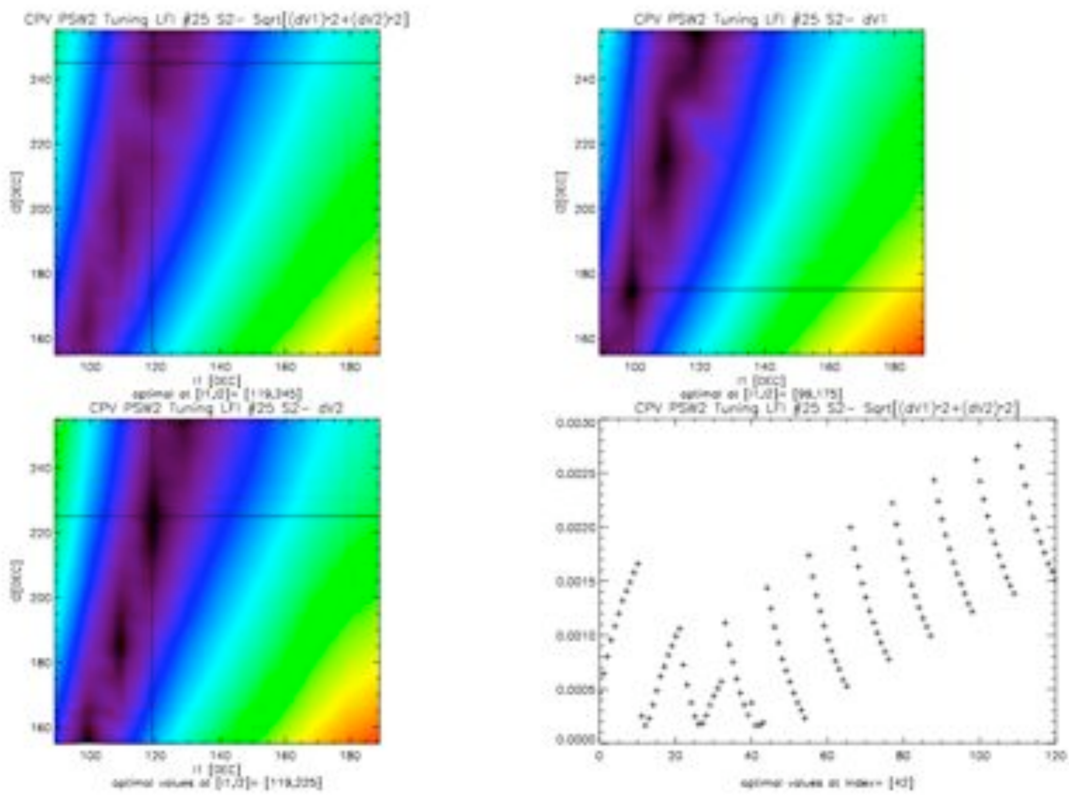

CPV PSW2 Tuning LFI #24 S1- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #24 S1- dV1
CPV PSW2 Tuning LFI #24 S1- dV2
CPV PSW2 Tuning LFI #24 S1- Sqrt[(dV1)^2+(dV2)^2]

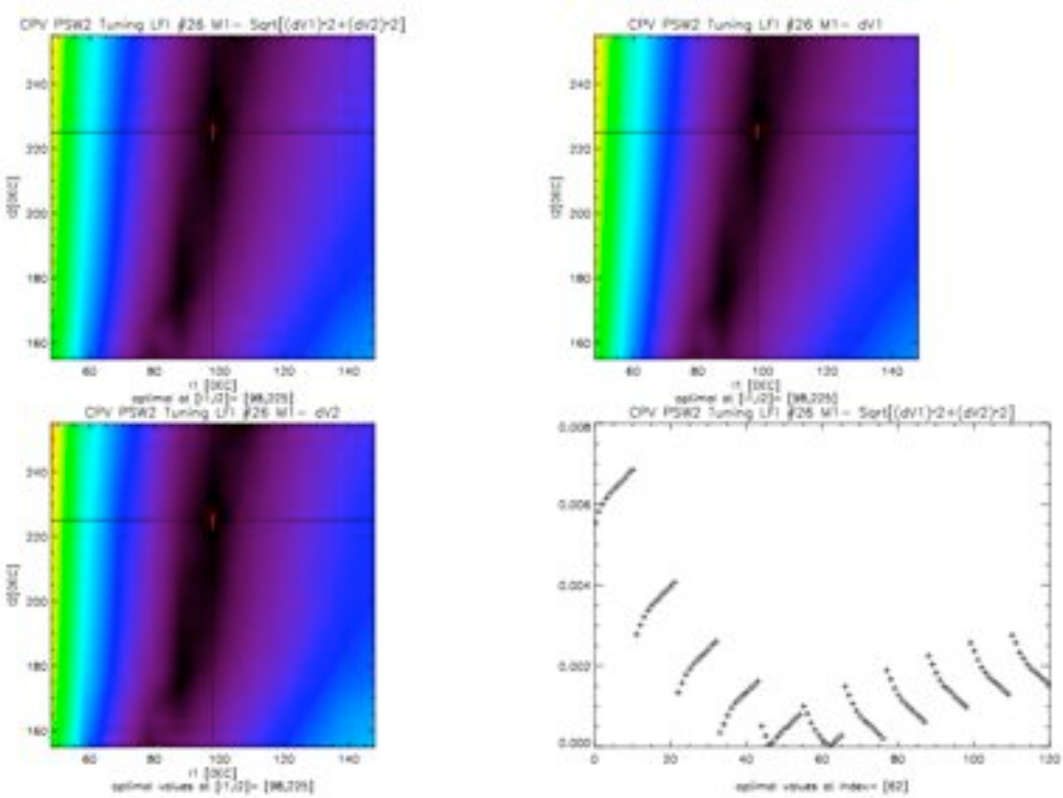

CPV PSW2 Tuning LFI #24 S2- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #24 S2- dV1
CPV PSW2 Tuning LFI #24 S2- dV2
CPV PSW2 Tuning LFI #24 S2- Sqrt[(dV1)^2+(dV2)^2]

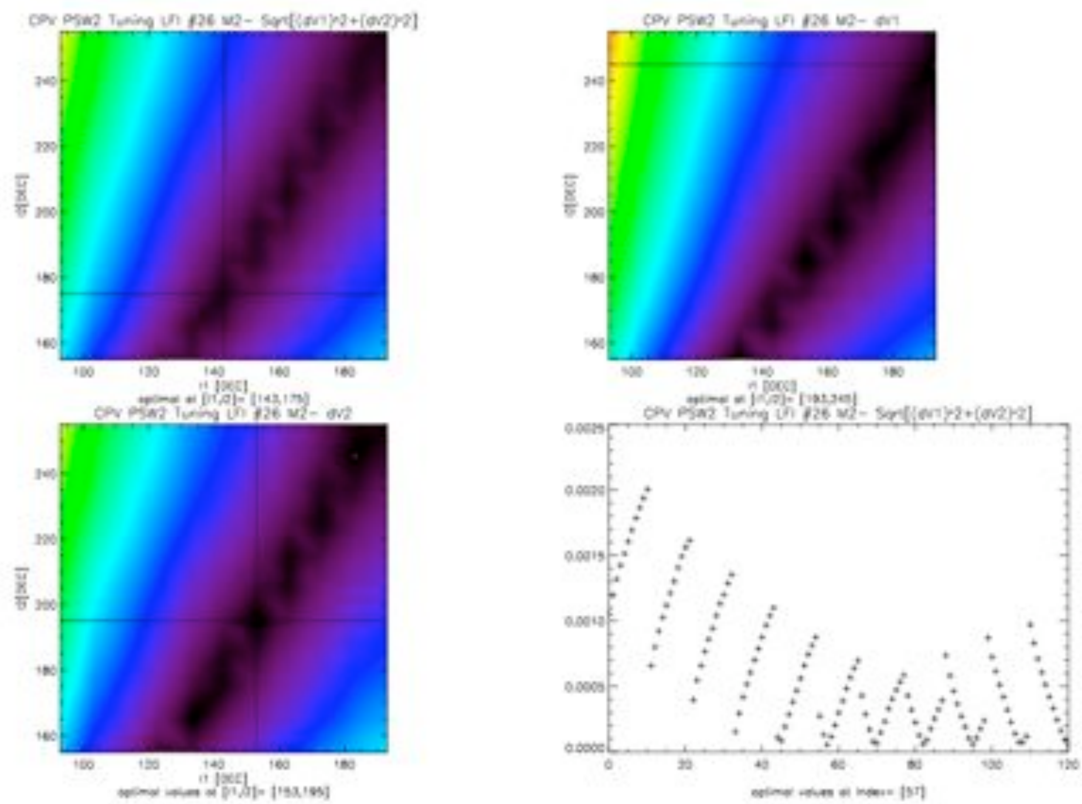


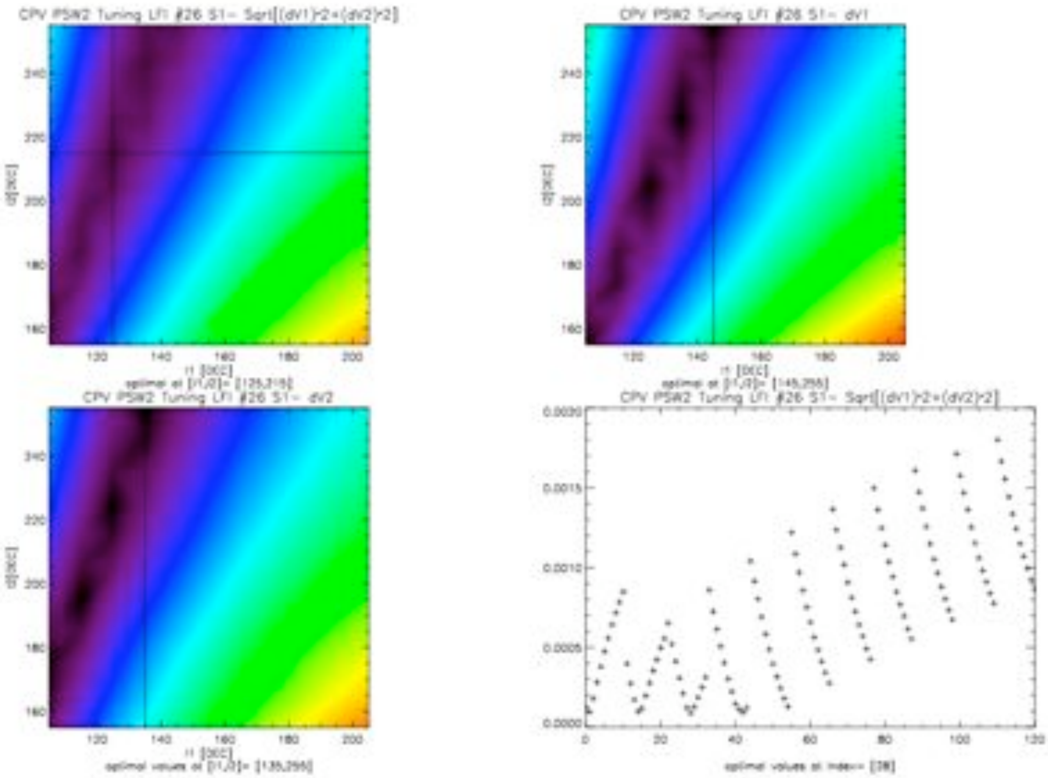


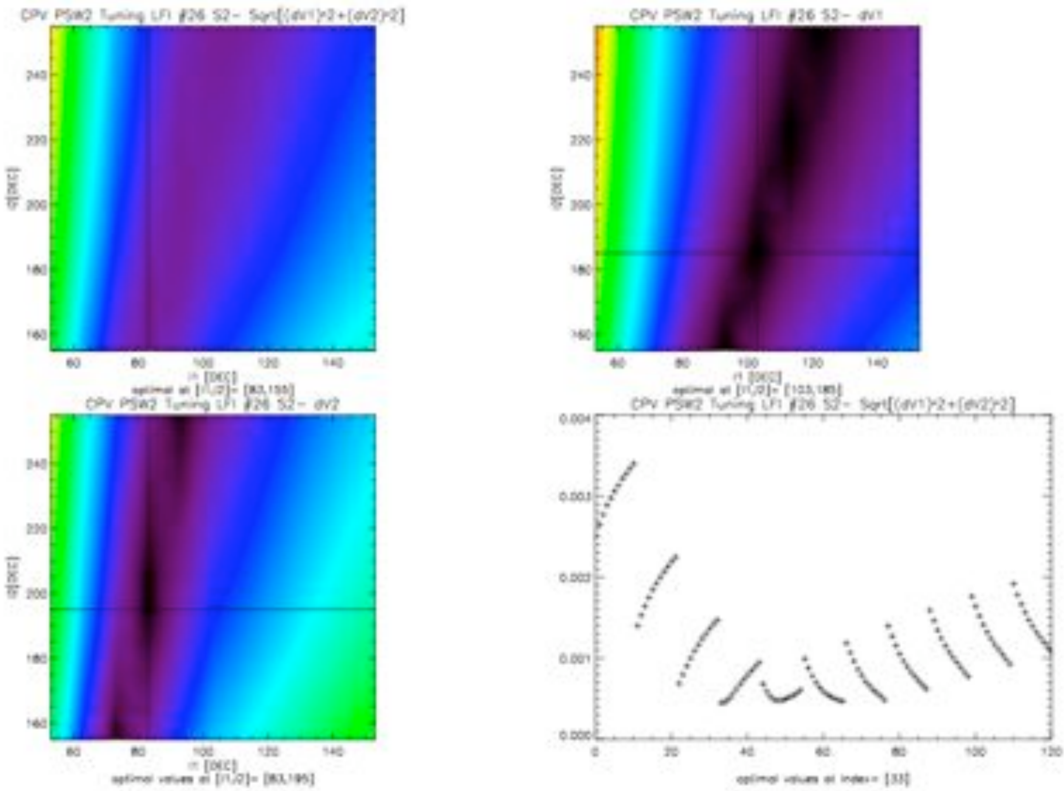

CPV PSW2 Tuning LFI #25 S1- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #25 S1- dV1
CPV PSW2 Tuning LFI #25 S1- dV2
CPV PSW2 Tuning LFI #25 S1- Sqrt[(dV1)^2+(dV2)^2]

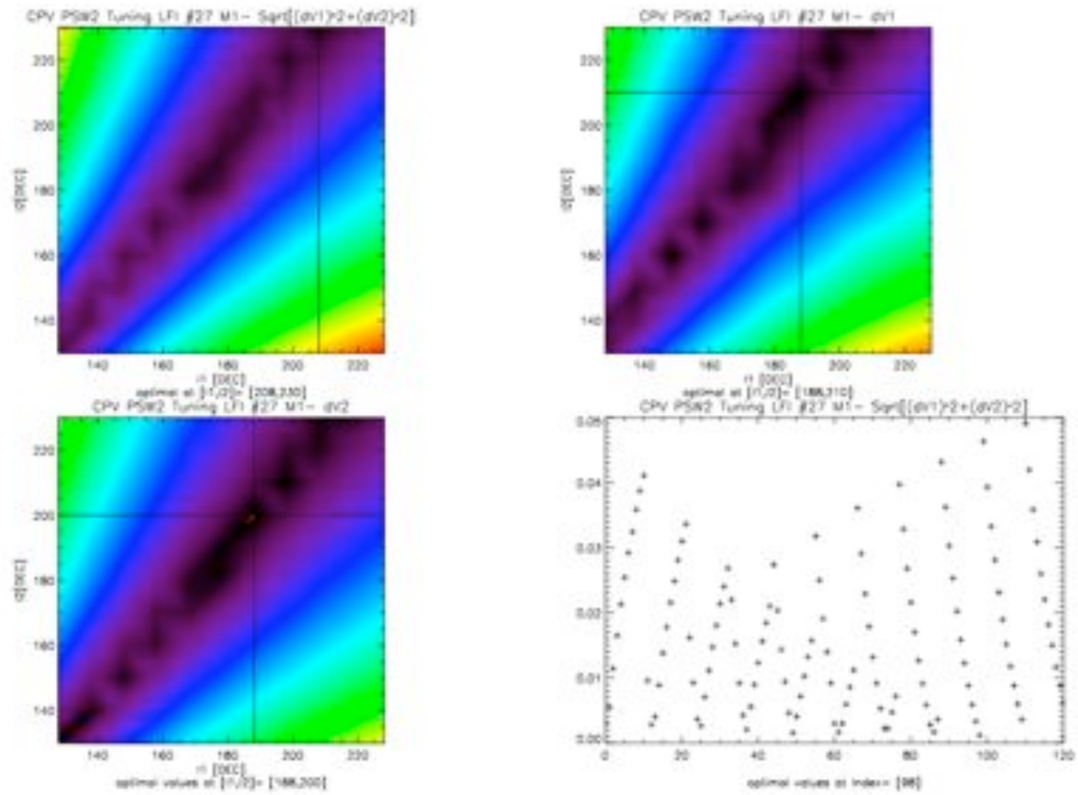

CPV PSW2 Tuning LFI #25 S2- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #25 S2- dV1
CPV PSW2 Tuning LFI #25 S2- dV2
CPV PSW2 Tuning LFI #25 S2- Sqrt[(dV1)^2+(dV2)^2]

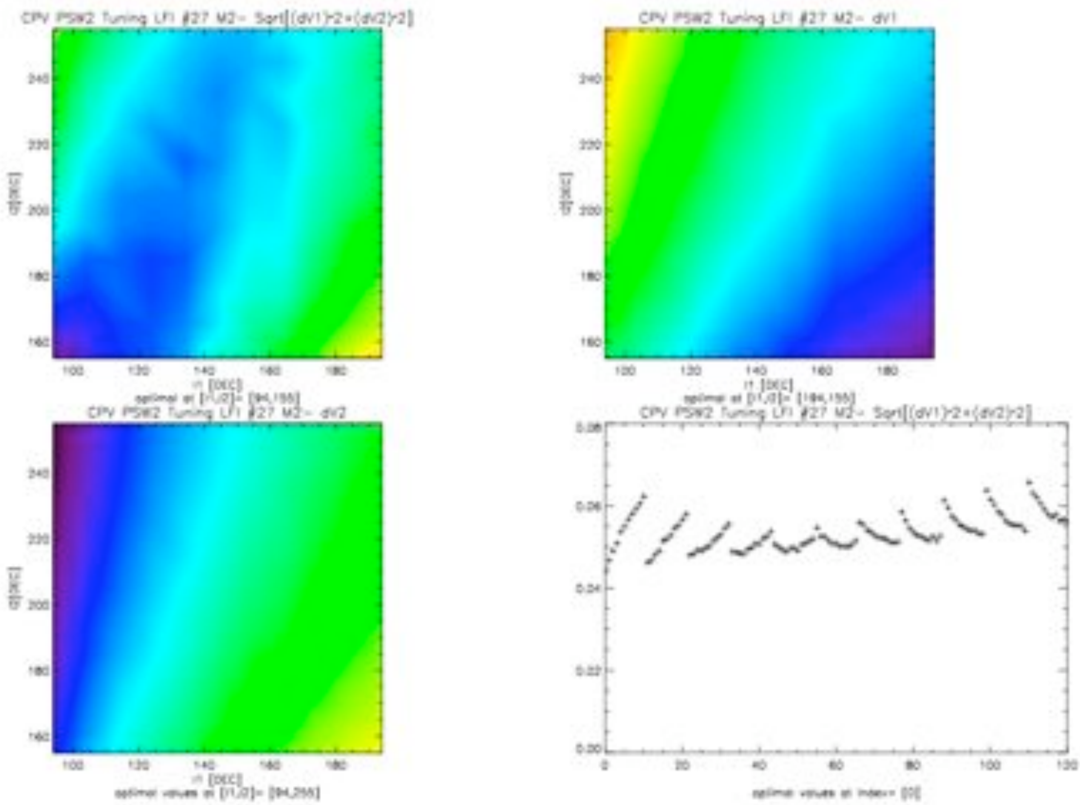

CPV PSW2 Tuning LFI #26 M1- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #26 M1- dV1
optimal at [t1,t2]= [98,225]
CPV PSW2 Tuning LFI #26 M1- dV2
optimal values at [t1,t2]= [98,225]
CPV PSW2 Tuning LFI #26 M1- Sqrt[(dV1)^2+(dV2)^2]
optimal values at index= [62]

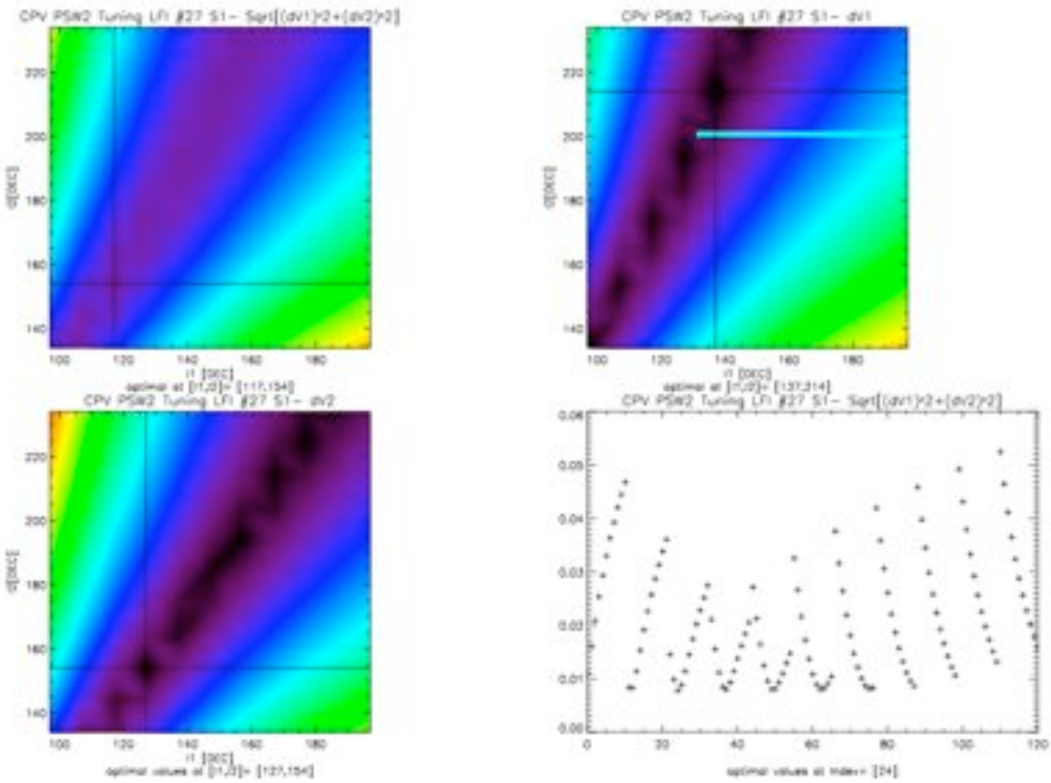

CPV PSW2 Tuning LFI #26 M2- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #26 M2- dV1
optimal at [t1,t2]= [143,175]
optimal at [t1,t2]= [183,245]
CPV PSW2 Tuning LFI #26 M2- dV2
optimal values at [t1,t2]= [153,195]
CPV PSW2 Tuning LFI #26 M2- Sqrt[(dV1)^2+(dV2)^2]
optimal values at index= [57]

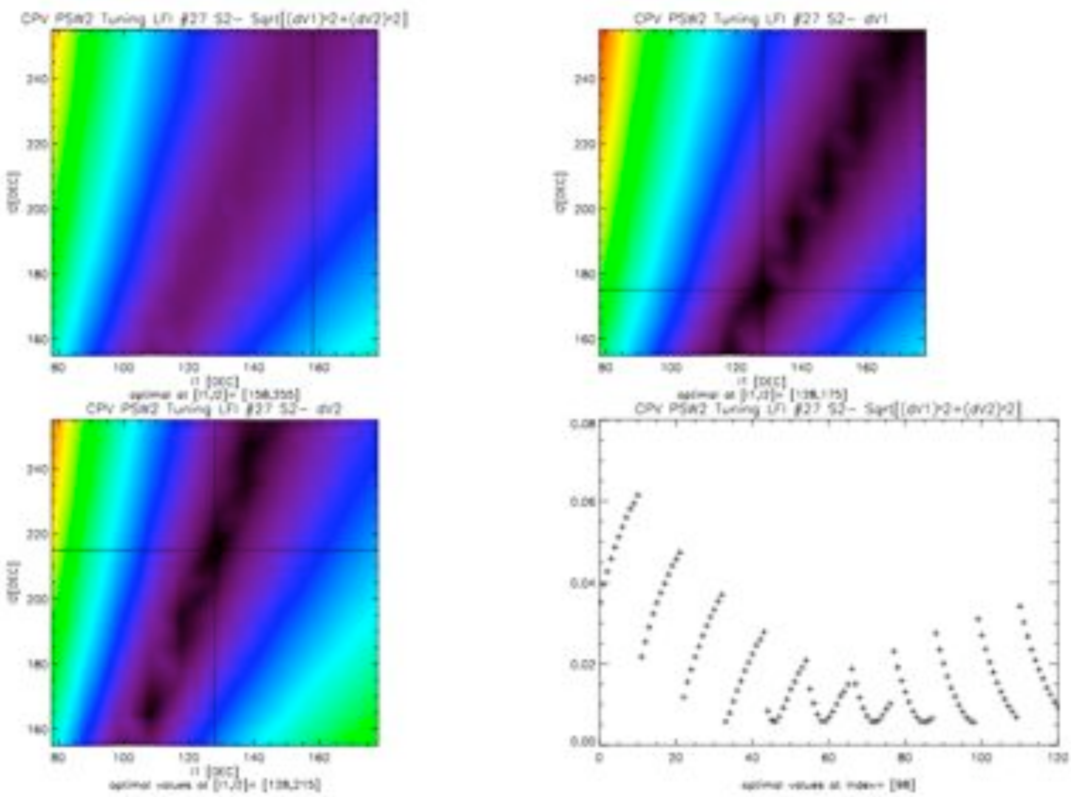

CPV PSW2 Tuning LFI #26 S1- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #26 S1- dV1
CPV PSW2 Tuning LFI #26 S1- dV2
CPV PSW2 Tuning LFI #26 S1- Sqrt[(dV1)^2+(dV2)^2]
optimal values at index= [38]

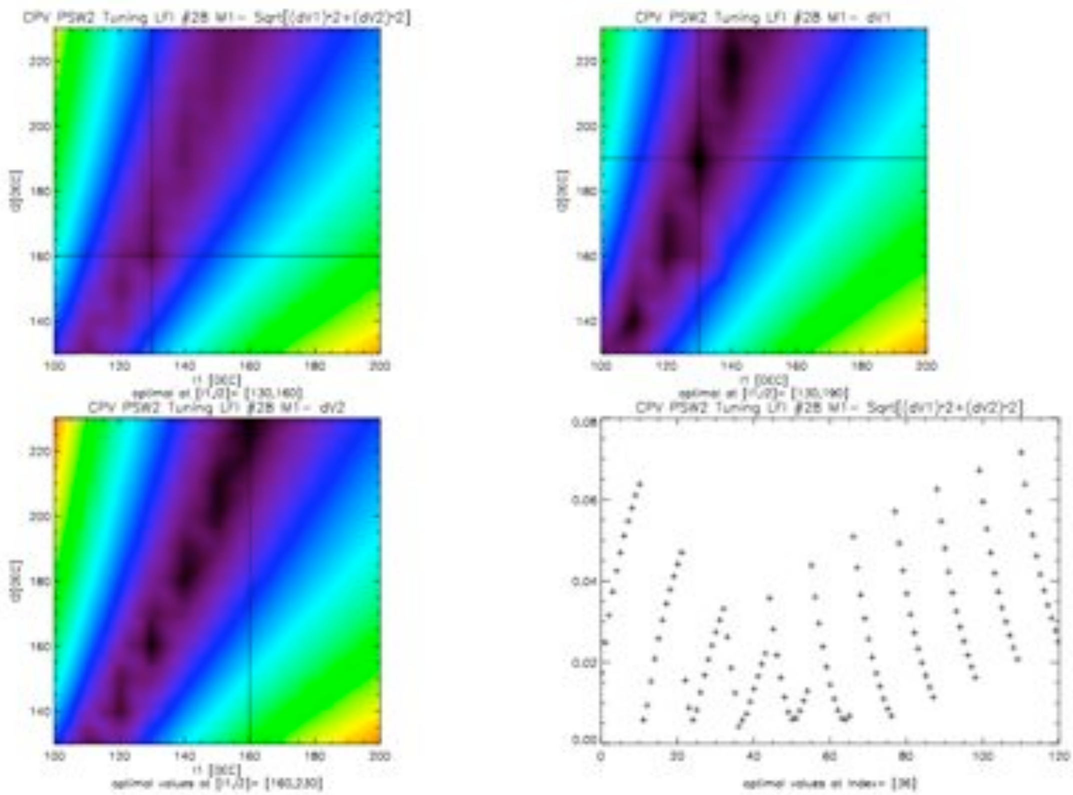

CPV PSW2 Tuning LFI #26 S2- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #26 S2- dV1
CPV PSW2 Tuning LFI #26 S2- dV2
CPV PSW2 Tuning LFI #26 S2- Sqrt[(dV1)^2+(dV2)^2]
optimal values at index= [33]

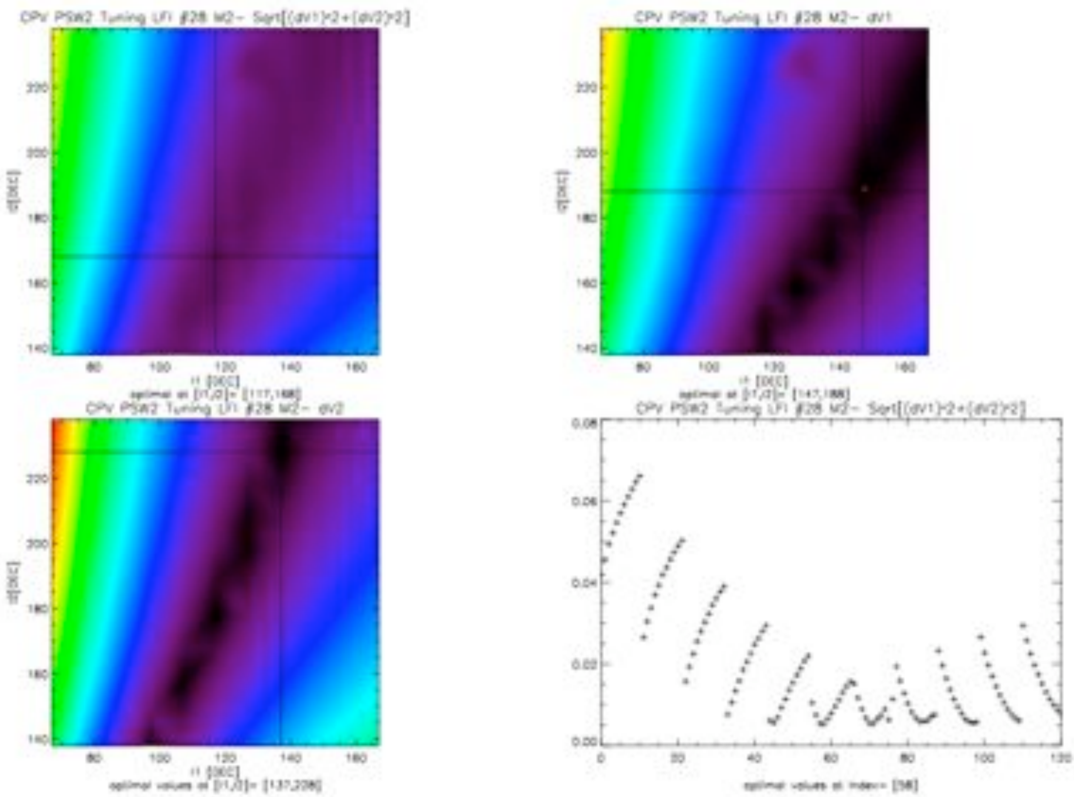

CPV PSW2 Tuning LFI #27 M1- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #27 M1- dV1
CPV PSW2 Tuning LFI #27 M1- dV2
CPV PSW2 Tuning LFI #27 M1- Sqrt[(dV1)^2+(dV2)^2]

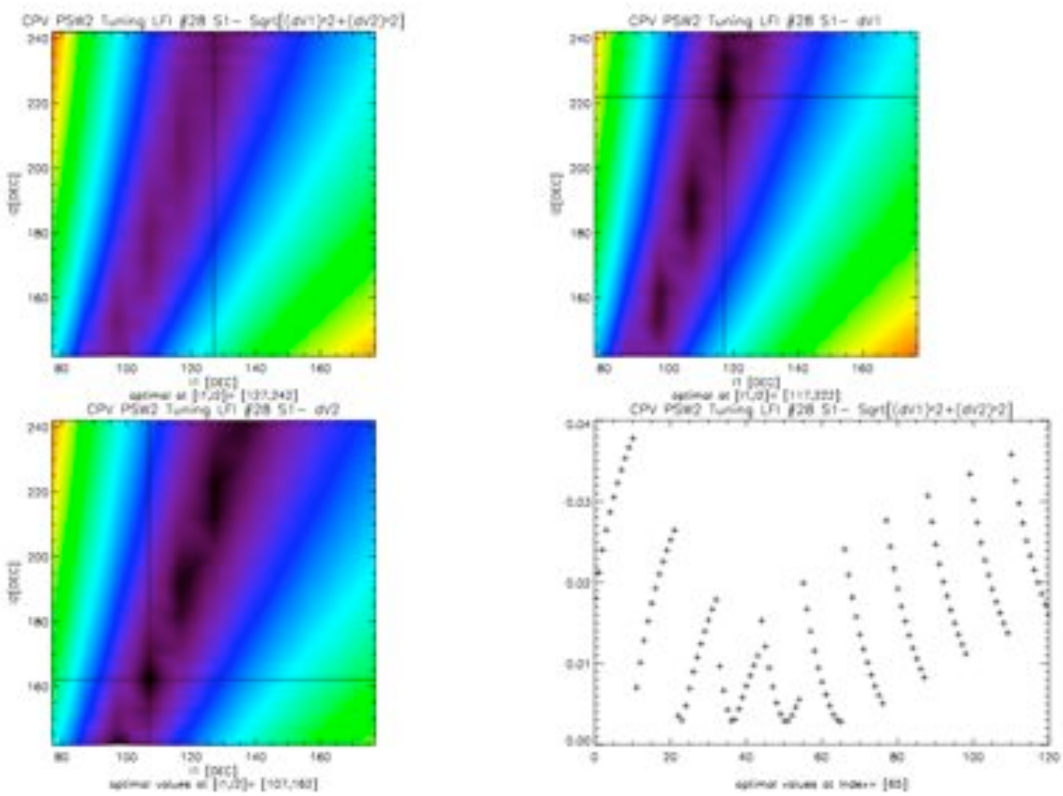

CPV PSW2 Tuning LFI #27 M2- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #27 M2- dV1
CPV PSW2 Tuning LFI #27 M2- dV2
CPV PSW2 Tuning LFI #27 M2- Sqrt[(dV1)^2+(dV2)^2]

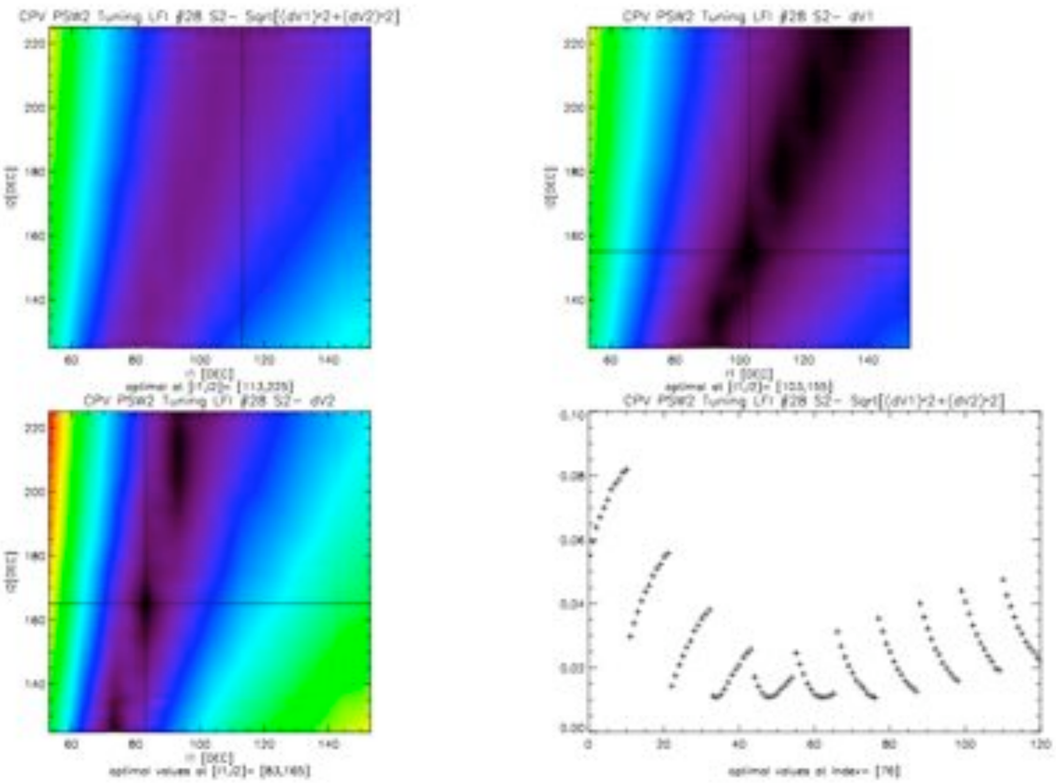

CPV PSW2 Tuning LFI #27 S1- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #27 S1- dV1
CPV PSW2 Tuning LFI #27 S1- dV2
CPV PSW2 Tuning LFI #27 S1- Sqrt[(dV1)^2+(dV2)^2]


CPV PSW2 Tuning LFI #27 S2- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #27 S2- dV1
CPV PSW2 Tuning LFI #27 S2- dV2
CPV PSW2 Tuning LFI #27 S2- Sqrt[(dV1)^2+(dV2)^2]


CPV PSW2 Tuning LFI #28 M1- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #28 M1- dV1
CPV PSW2 Tuning LFI #28 M1- dV2
CPV PSW2 Tuning LFI #28 M1- Sqrt[(dV1)^2+(dV2)^2]


CPV PSW2 Tuning LFI #28 M2- Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #28 M2- dV1
CPV PSW2 Tuning LFI #28 M2- dV2
CPV PSW2 Tuning LFI #28 M2- Sqrt[(dV1)^2+(dV2)^2]


CPV PSW2 Tuning LFI #28 S1– Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #28 S1– dV1
CPV PSW2 Tuning LFI #28 S1– dV2
CPV PSW2 Tuning LFI #28 S1– Sqrt[(dV1)^2+(dV2)^2]


CPV PSW2 Tuning LFI #28 S2– Sqrt[(dV1)^2+(dV2)^2]
CPV PSW2 Tuning LFI #28 S2– dV1
CPV PSW2 Tuning LFI #28 S2– dV2
CPV PSW2 Tuning LFI #28 S2– Sqrt[(dV1)^2+(dV2)^2]

9 PSW Verification: Results and Conclusions

Due to the oscillascion in the RCA24 and the saturation on the RCA27 the purpose of this test was not reached. Even if at first order the PSW tuning test results were confirmed, any second order effects on PSW tuning due to the different amplifier biases may not be found with this test.

Appendix A PSW Tuning 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	6.01.18	0.44.42		28-2			

	tuning for ACA2							
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 Soft S. On proc	6.46.12	0.00.06	1623992371.28	28-1,2			
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 disabled
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 Configuration as current configuration	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 selected 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 configuration	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 ---